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CONTENTS

Fire Protection, Detection and Extinction in Ships	G. Coggon
Surveying O.B.O's and Large Bulk Carriers ...	G. S. McIntosh
Some Notes on Writing Damage Reports ... ... (No Discussion)	L. D. Phillip
Some Practical Aspects of Moulding G.R.P. Yachts and Small Craft	J. Tyler & R. Musters
Lloyd's Register and the Marine Engine Builder ...	A. Schiff
Index to Transactions (1920–1975)	R. J. Hook

Lloyd's Register Technical Association

FIRE PROTECTION, DETECTION AND EXTINCTION IN SHIPS

G. Coggon

Paper No. 1. Session 1974-75

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Hon. Sec. A. Wardle
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TABLE OF CONTENTS

Section 1 **INTRODUCTION**

Section 2 **THE NATURE OF FIRE**

Section 3 **FIRE PROTECTION**

3.1 Definition of terms
3.1.1 The standard fire test
3.1.2 Non-combustible materials
3.1.3 'A' Class or Fire resisting divisions
3.1.4 'B' Class or Fire retarding divisions
3.1.5 'C' Class divisions
3.1.6 Low flame spread
3.2 General Principles
3.3 Passenger ships
3.3.1 Structure
3.3.2 Main fire subdivision
3.3.3 Protection of accommodation and service spaces
3.3.4 Openings in 'A' Class divisions
3.3.4.1 Doors
3.3.4.2 Ventilation ducts
3.3.4.3 Electric cables
3.3.4.4 Pipes
3.3.5 Insulation of 'A' Class divisions
3.3.6 Construction of 'B' Class divisions
3.3.6.1 Openings in 'B' Class divisions
3.3.6.2 Doors
3.3.7 Deck coverings
3.3.8 Protection of stairways
3.3.9 Protection of lifts
3.3.10 Ventilation systems
3.3.11 Skylights
3.3.12 Miscellaneous items
3.3.13 Means of escape
3.4 Cargo ships
3.4.1 Structure
3.4.2 Corridors
3.4.3 Deck coverings
3.4.4 Stairways

Section 4 **FIRE DETECTION**

4.1 Passenger ships
4.2 Machinery spaces
4.3 Types of detectors
4.3.1 Automatic sprinkler systems
4.3.2 Heat detectors
4.3.3 Combustion gas detectors
4.3.4 Flame detectors

Section 5 **FIRE EXTINCTION**

5.1 Definition and designation of classes of fire
5.2 Fire extinguishing agents
5.2.1 Water
5.2.2 Steam
5.2.3 Carbon dioxide
5.2.4 Foam
5.2.4.1 Chemical foam
5.2.4.2 Air foam
5.2.4.3 Protein foam
5.2.4.4 Fluoroprotein foam
5.2.4.5 Synthetic foam
5.2.4.6 Aqueous film-forming foam
5.2.4.7 Alcohol foam
5.2.5 Dry powders
5.2.6 Inert gas
5.2.7 Nitrogen
5.2.8 Halogen based vaporizing liquids
5.3 Fire extinguishing systems and appliances
5.3.1 The wash deck and fire main
5.3.1.1 General
5.3.1.2 Fire pumps
5.3.1.3 Piping
5.3.1.4 Hoses and nozzles
5.3.2 Water spray systems
5.3.2.1 General
5.3.2.2 Machinery spaces and cargo pump rooms
5.3.2.3 Vehicle 'tween decks
5.3.3 Steam smothering systems
5.3.4 Carbon dioxide systems
5.3.4.1 General
5.3.4.2 Quantity
5.3.4.3 Storage
5.3.4.4 Distribution
5.3.4.5 Controls
5.3.4.6 Alarms
5.3.5 Foam systems
5.3.5.1 General
5.3.5.2 Fixed low expansion foam systems in machinery spaces and cargo pump rooms
5.3.5.3 High expansion foam systems for machinery spaces and cargo pump rooms
5.3.5.4 Deck foam systems
5.3.5.5 Medium expansion foam systems
5.3.6 Dry powder systems
5.3.6.1 General
5.3.6.2 Piped systems

5.3.6.3 Deck units
5.3.7 Inert gas systems
5.3.7.1 General
5.3.7.2 Inert gas systems using boiler flue gases
5.3.7.3 Inert gas systems with independent generators
5.4 Portable fire extinguishers
5.4.1 General
5.4.2 Water (soda acid) extinguishers
5.4.3 Water (gas cartridge) extinguishers
5.4.4 Chemical foam extinguishers
5.4.5 Air foam extinguishers (also referred to as mechanical foam extinguishers)
5.4.6 Carbon dioxide extinguishers
5.4.7 Dry powder extinguishers
5.4.8 Vaporizing liquid extinguishers
5.5 Firemen's outfits
5.5.1 General
5.5.2 Self-contained breathing apparatus

Section 6 **REGULATIONS**

Section 7 **FIRE AND EXPLOSION CASUALTY RECORDS**

Section 8 **CONCLUSIONS**

ACKNOWLEDGEMENT

BIBLIOGRAPHY

APPENDIX 1 Survey and Test Procedures for the Fire Main

APPENDIX 2 Survey and Test Procedures for Carbon Dioxide Fixed Systems

APPENDIX 3 Survey and Test Procedures for Fixed Foam Systems

APPENDIX 4 Survey and Test Procedures for Portable Fire Extinguishers

APPENDIX 5 Survey and Test Procedures for Breathing Apparatus

APPENDIX 6 List of Plans required to be submitted for all ships intended for the Society's Classification.

FIRE PROTECTION, DETECTION AND EXTINCTION IN SHIPS

By G. COGGON*

1 INTRODUCTION

The scope of this subject is so vast that a paper of reasonable size can present little but a resumé of the problems involved and the methods of solving them. It is nevertheless hoped, that it will be of some practical benefit to members of the Association in carrying out their surveys, and that it will provoke an interest in a fascinating subject, which is of increasing importance in the work of the Society.

For as long as ships have put to sea, fire has been one of the major hazards involved, and a phenomenon to be feared by all who venture to sail in them.

The cost of the damage, which has been wreaked by fire in ships, and the accompanying loss of life, and suffering due to injury, is incalculable.

Apart from requirements for the machinery spaces and cargo pump rooms, Lloyd's Register of Shipping did not become interested in fire protection until 1952, when the 1948 International Convention for the Safety of Life at Sea, came into force, and it became mandatory for passenger ships to have a valid Safety Certificate, and cargo ships to have a valid Safety Equipment Certificate.

At that time, the Society was authorised by the Governments of Liberia and Panama, under the terms of the Convention, to carry out the necessary surveys and issue certificates to ships registered in those countries. In the course of time, other countries followed, and the Society now has general authorisation from 34 countries.

In 1965, the 1948 Convention was superseded by the 1960 Convention which, in addition to the above-mentioned certificates, required that cargo ships have a valid Cargo Ship Safety Construction Certificate.

The Passenger Ship Safety Certificate relates to, *inter alia*, fire protection, detection and extinction and general fire precautions.

The Cargo Ship Safety Equipment Certificate relates to, *inter alia*, fire extinguishing appliances and fire control plans.

The Cargo Ship Safety Construction Certificate relates to, *inter alia*, fire protection and general fire precautions.

Requirements for fire protection first appeared in the Society's Rules and Regulations, as a condition of Class in 1950, and referred only to machinery spaces. In 1963, Chapter F was extended to cover the protection of the entire ship.

The Society's interest now extends to the International Association of Classification Societies (IACS), under whose auspices Lloyd's Register provide, the Secretariat for the Working Party on Fire Protection and Tanker Safety, and the IACS delegation to the IMCO Sub-Committee on Fire Protection. The international requirements for fire protection in ships, are currently being amended, and through these agencies, the Society has an opportunity to contribute to the development of the regulations which eventually will have to apply.

In 1966 the Assembly of IMCO adopted amendments to the requirements for the fire protection of passenger ships and these are set out in Part G of Chapter II of the 1960 Convention. These amendments have not been implemented internationally, but are applied by the U.S.A. to all passenger ships using ports in that country.

The Society carries out surveys and issues statements of compliance with Part G.

In 1967 the Assembly of IMCO adopted regulations in respect of passenger ships carrying more than 36 passengers and these were intended to replace Regulation 31 of Part C and Parts D, E, F and G of Chapter II of the 1960 Convention in relation to such ships. These regulations are set out in Part H of Chapter II.

Part H has not yet been ratified by a sufficient number of countries to make it obligatory internationally. However, steps are now being taken for its inclusion in the Convention which is scheduled to take place in 1974.

Some owners require their new passenger ships and conversions of existing ships to comply with Part H.

Part H is particularly useful in that it has requirements for passenger ships with enclosed spaces intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion, into and from which such vehicles can be driven and to which passengers have access. There are no provisions for such spaces under the 1960 Convention.

Parts G and H are published separately from the 1960 Convention.

New regulations have been adopted by the Assembly of IMCO in respect of oil tankers and combination carriers, such as O.B.O. ships. These are not at present obligatory, but preparations are being made for their inclusion in the 1974 Convention. Some owners, recognising the inadequacy of the requirements for such ships under the 1960 Convention, elect to have their new ships equipped in accordance with all or part of the new requirements.

2 THE NATURE OF FIRE

Fire is a chemical action in which elements, such as carbon and hydrogen, are combined with oxygen, resulting in a release of energy in the form of heat and light.

When some substances are heated, they exude vapours, and when these vapours are heated further, a temperature is reached at which vapour is evolved in sufficient quantity to be ignited if a source of ignition is present. This temperature is called the FLASH POINT or IGNITION TEMPERATURE.

If the unignited vapours are heated still further, they reach a temperature at which they will ignite without the presence of a source ignition. This temperature is called the AUTO-IGNITION TEMPERATURE.

Fire requires the presence of three essential elements; fuel, heat, and a supply of free oxygen, usually in air.

It follows that if one is to prevent the occurrence of fire, one must ensure that one or more of these essentials is excluded. Similarly, for the successful extinction of a fire, one or more of the elements must be removed.

There are exceptions to the general principle that air is necessary to form a flammable mixture. The oxygen contained in nitrates and chlorates, will support combustion without

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the presence of air, and these substances present serious explosion risks when carried in the holds of ships. Fires in nitrates and chlorates are extinguished by the copious application of water through open-ended hoses, led through open hatches.

In conditions where there are combustible materials, so situated in relation to a fire that they are capable of ignition, a fire will spread upwards and outwards from the original point of ignition, by the convection, radiation and conduction of heat.

Between 75 and 85 per cent of the heat transferred away from a fire is accounted for by convection. Heat is released from a fire at temperatures in the region of 800 to 1200°C. At these temperatures air is expanded to about a quarter of its density at normal atmospheric temperatures, and is entrained by the hot gases produced by the fire, to form a convection current, travelling upwards with a high velocity as a turbulent column, spreading heat above and around the area of combustion. This results in, among other things, an inflow of cooler, denser fresh air to the base of the fire, whereby the rate of combustion or intensity of the fire, is increased and its rate of growth accelerated.

These convection currents can quickly raise the temperature of combustible materials in their path to the ignition point and, where unrestricted, can cause the fire to spread rapidly to areas remote from the original outbreak, either directly, or through secondary outbreaks caused by the ignition of combustible vapours contained in the gases from the fire, which have not been consumed because of oxygen starvation within the fire, but on reaching supplies of fresh air, some distance from the fire, burst into flame. This latter phenomenon can be seen when areas of flame appear in the smoke at considerable distances from a large fire.

When a fire occurs in an enclosed compartment the hot gases rise to the ceiling, where they spread out to form a hot layer. As the fire proceeds, this layer increases in temperature and depth and when all the oxygen has been used up, the fire dies down to a smouldering mass with an atmosphere above consisting of combustion gases and unburned combustible vapours at or above their ignition temperature. If a door or window is opened fresh air will be drawn into the compartment and the unburned combustible vapours will burst into flame with almost explosive force. This phenomenon is referred to as FLASH-OVER and constitutes the division between a minor and a major outbreak.

Radiation is responsible for the spread of fire to a lesser but significant degree. Combustible materials laterally adjacent to a fire may be unaffected by convection currents, but heat radiated from the flames may cause the evolution of vapours which are drawn toward the fire and ignited.

Fire may also be spread by the conduction of heat by materials with suitable characteristics. Ships are largely constructed of steel, which is a good conductor of heat, and special precautions must be taken to restrict the spread of fire from one compartment to another by the conduction of heat through the structure.

It is a fundamental fact that fire creates the conditions for its own growth and, with growth, its potential for growth increases.

It is essential to safety that fire should be controlled and, if possible, extinguished without delay, otherwise it may develop to proportions at which it will be beyond the capacity of the available extinguishing equipment. This is even more important on board ship than on land, since the equipment available is very limited and help from outside sources probably will be unavailable.

In addition to heat and flames, most fires produce smoke and an assortment of gases, some of which are toxic or asphyxiating.

Smoke obscures the location of a fire so that one of the major problems of fire fighting is that of locating the seat of the fire. It also obscures escape routes, thus creating difficulties for personnel who are trying to escape from their cabins, perhaps on the lower decks, to the lifeboat embarkation deck, or assembly positions.

The principal gases present in a fire are carbon monoxide and carbon dioxide, although significant quantities of other gases may also be present, depending on the materials involved.

Carbon monoxide is preferentially absorbed by the haemoglobin of the blood, and deprives the body of oxygen; two to three breaths of this gas at a concentration of 1·28 per cent in air produces unconsciousness and death within two to three minutes.

Carbon dioxide is not so toxic; unconsciousness occurs at a concentration of about 9 per cent, however, the increased breathing rate, stimulated by the inhalation of small quantities, increases the intake of other combustion products which may also be toxic or asphyxiating.

The physiological effects of this combination of combustion products, are to incapacitate a person through its powerful irritant action on the eyes, nose, throat and lungs, and to partially or totally reduce vision.

Psychologically, the sight or smell of smoke may induce panic, even when it appears in an area as yet unaffected by heat or flames.

Of the deaths which are attributed to fire, the vast majority are caused by the asphyxiating and toxic effects of smoke and the accompanying combustion gases.

3 FIRE PROTECTION

3 . 1 Definition of terms

Before proceeding to the methods of fire protection, it is necessary to define some of the items which are used in this respect.

3 . 1 . 1 The standard fire test

This is a test in which specimens of materials which are intended to be used in the construction of fire bulkheads and decks are exposed to a fire whose development is regulated according to a standard time/temperature scale.

The specimens are approximately 4,65 sq. m (50 sq. ft) in area and have a height of 2,44 m (8 ft). They must resemble as closely as possible the construction of the actual division and include, where appropriate, at least one joint. Fig. 1 shows the standard fire test time/temperature curve.

3 . 1 . 2 Non-combustible materials

These are materials which neither burn, nor give off flammable vapours in sufficient quantity to ignite at a pilot flame or other ignition source when heated to approximately 750°C (1382°F). This quality has, until recent years, been referred to as incombustibility, but IMCO have now decided that it shall be referred to as non-combustibility.

It will be seen that it is not an absolute term, but only applies below the temperature stated. It is quite possible for a material which burns at temperatures above 750°C to be referred to as non-combustible, provided it complies with the above definition.

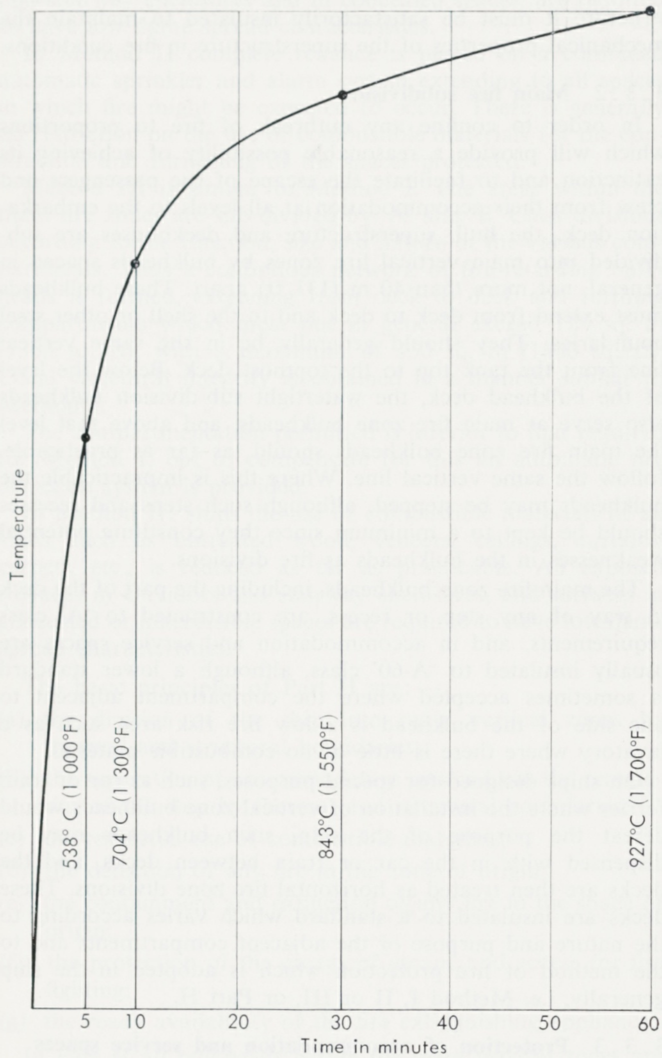


FIG. 1

Standard fire test curve.

Non-combustible materials are inorganic, although not all inorganic materials are non-combustible. Organic materials cannot be rendered non-combustible by any known treatment, whether by the application of surface coatings or impregnated with chemicals. Although such treatments may reduce the susceptibility to ignition and retard the development of a fire, they neither reduce the combustion contents nor significantly affect the process of decomposition under heat. Eventually, flammable vapours are given off and little difference is made to the combustibility in a fully developed fire. All organic materials and all plastics as they are at present known, are combustible by this standard.

3.1.3 'A' Class or fire resisting divisions

These are divisions formed by bulkheads or decks which comply with the following:—

(1) they shall be constructed of steel or other equivalent material;

(2) they shall be suitably stiffened;

(3) they shall be so constructed as to be capable of preventing the passage of smoke and flame to the end of the one-hour standard fire test;

(4) they shall be insulated with approved incombustible materials such that the average temperature of the unexposed side will not rise more than 139°C (250°F) above the original temperature, nor will the temperatuure, at any one point, including any joint, rise more than 180°C (325°F) above the original temperature, within the time listed below:—

Class A-60	60 minutes
Class A-30	30 minutes
Class A-15	15 minutes
Class A-0	0 minutes

(5) the Administration may require a test of a prototype bulkhead or deck to ensure that it meets the above requirements for integrity and temperature rise.

3.1.4 'B' Class or fire retarding divisions

These are those divisions formed by bulkheads, decks, ceilings or linings which comply with the following:—

(1) they shall be so constructed as to be capable of preventing the passage of flame to the end of the first one half-hour of the standard fire test;

(2) they shall have an insulation value such that the average temperature of the unexposed side will not rise more than 139°C (250°F) above the original temperature, nor will the temperature at any one point, including any joint, rise more than 225°C (405°F) above the original temperature, within the time listed below:—

Class B-15	15 minutes
Class B-0	0 minutes

(3) they shall be constructed of approved non-combustible materials and all materials entering into the construction and erection of 'B' Class divisions shall be non-combustible.

(4) A prototype division is required to be tested to ensure that it meets the above requirements for integrity and temperature rise.

The above definition is that given in the amendments to the 1960 Safety Convention. Since these amendments are not yet mandatory, it is still permissible to construct 'B' Class divisions of combustible materials such as chipboard.

3.1.5 'C' Class divisions

These are divisions constructed of approved non-combustible materials. They need meet no requirements relative to the passage of smoke and flame, nor any limitation of temperature rise.

In other words, they have no required fire resistance, but will not contribute to the fire load.

3.1.6 Low flame spread

One of the ways by which fire grows is by the spread of flames across a surface. This characteristic varies in different materials, in some such as bare wood it is low, but in others, such as organic foams, it is very high. It is therefore important to control the use of materials with a high flame spread characteristic. The flame spread characteristic of a material is determined by a laboratory test and is categorised as Class 1, 2, 3 or 4.

3.2 General principles

The ultimate aim of all fire protective measures must be to prevent the outbreak of fire. It has, however, to be admitted that in ships this is an impracticable ideal and we have to be satisfied with reducing the possibility of fire to a minimum.

This is achieved by reducing, as far as practicable, the amount of combustible material used in the construction and furnishings.

In the past, this has resulted in some very austere vessels, but with modern materials much can now be achieved without losing too much aesthetic effect.

Having admitted the possibility of fire it is necessary to ensure the containment of any outbreak to limits which will be within the fire fighting capability of the ship's crew and equipment. This is achieved by dividing the ship into fire zones and by separating, as far as practicable, high fire risk areas such as cargo spaces, machinery spaces and accommodation and service areas. Then if the crew are to have a reasonable chance of extinguishing a fire, it is essential that it is detected and dealt with as soon as possible. To this end automatic fire detection and manual fire alarm systems are fitted and fire patrols mounted. A variety of appliances must be provided for dealing with fires of all anticipated types and magnitudes, and the crew must be trained to use them efficiently.

It is imperative that all control stations such as the navigating bridge, the radio room, the emergency generator room, the steering gear compartment and the fire control stations are protected for as long as possible from fires in the adjacent compartments.

As in all fire fighting, both on land and at sea, it has to be admitted that there will inevitably be a point where a fire will reach a magnitude when it is beyond the capability of the appliances available and, when that point is reached, the only recourse for any personnel involved is to escape. To that end great care must be taken over the disposition and protection of escape corridors and stairways, and the siting of lifeboats and life rafts. It will therefore be seen that marine fire protection is a combination of passive and active defence, consisting of structural measures to minimise the occurence and magnitude of fires, and means of extinguishing fires, together forming an integrated system. The international regulations now in force are based on a capability to withstand a fire of unrestricted intensity for one hour. In the event of failure to extinguish such a fire, this should allow ample time to accomplish the safe abandonment of the ship.

Under the SOLAS regulations ships are categorised as passenger ships and cargo ships, although regulations and codes are now being developed in IMCO and IACS for the protection of specialised types of ships such as car ferries, chemical carriers, gas carriers and fishing vessels.

3.3 Passenger ships

3.3.1 Structure

The hull, superstructure, structural bulkheads, decks and deckhouses are required to be constructed of steel or other equivalent material.

Where aluminium is used for the construction of a superstructure it must be satisfactorily insulated to maintain the mechanical properties of the superstructure in fire conditions.

3.3.2 Main fire subdivision

In order to confine any outbreak of fire to proportions which will provide a reasonable possibility of achieving its extinction and to facilitate the escape of the passengers and crew from their accommodation at all levels to the embarkation deck, the hull, superstructure and deckhouses are subdivided into main vertical fire zones by bulkheads spaced in general, not more than 40 m (131 ft) apart. These bulkheads must extend from deck to deck and to the shell or other steel boundaries. They should generally be in the same vertical line from the tank top to the topmost deck. Below the level of the bulkhead deck, the watertight sub-division bulkheads also serve as main fire zone bulkheads, and above that level the main fire zone bulkheads should, as far as practicable, follow the same vertical line. Where this is impracticable the bulkheads may be stepped, although such steps and recesses should be kept to a minimum since they constitute potential weaknesses in the bulkheads as fire divisions.

The main fire zone bulkheads, including the part of the deck in way of any step or recess, are constructed to 'A' class requirements, and in accommodation and service spaces are usually insulated to 'A-60' class, although a lower standard is sometimes accepted where the compartment adjacent to one side of the bulkhead is a low fire risk area such as a lavatory where there is little or no combustible material.

On ships designed for special purposes, such as car or train ferries where the installation of vertical zone bulkheads would defeat the purpose of the ship, such bulkheads may be dispensed with in the car or train between decks, and the decks are then treated as horizontal fire zone divisions. These decks are insulated to a standard which varies according to the nature and purpose of the adjacent compartments and to the method of fire protection which is adopted in the ship generally, i.e. Method I, II or III, or Part H.

3.3.3 Protection of accommodation and service spaces

There are four acceptable methods of protecting the accommodation and services spaces within the main vertical fire zones. These are referred to as Method I which is favoured by American authorities and is found in all American passenger ships; Method II which is favoured by the British authorities and several other European administrations; Method III which is favoured by the French authorities; and Part H which is intended as a replacement for Methods I, II and III, but is not yet in force.

In Method I an attempt is made to prevent the spread of fire within the main fire zones by an exclusive use of non-combustible materials for all bulkheads, linings, ceilings and insulants. Combustible materials may, however, be used for bulkhead facings, but the total volume of such facings, mouldings, decorations and veneers, must not exceed the equivalent of 2,54 mm (1/10 in) over the combined area of the walls and ceilings.

The standard of fire insulation of the bulkheads and decks depends on the characteristics of the spaces which they separate. Thus, any outbreak of fire should be confined to the compartment in which it occurs, long enough for it to be discovered by the fire patrol or other personnel, and the fire crew to be alerted. To facilitate a safe escape from any zone in which a fire occurs, all exposed surfaces in the corridors and stairway enclosures and in concealed spaces, are required to have low flame spread characteristics.

In Method II complete reliance is placed on a combined automatic sprinkler and alarm system extending to all spaces in which fire might be expected to occur. There is generally no restriction on the use of combustible materials for the construction and furnishing of the spaces protected.

Method III is similar to Method I. The areas within the main fire zones are sub-divided by 'A' and 'B' Class divisions according to the function, size and nature of the various compartments. Thus a continuous network of fire-retarding bulkheads is formed, extending from deck to deck and forming compartments which must not in general exceed 120 sq. m (1300 sq. ft), with a maximum of 150 sq. m (1600 sq. ft). Local structural integrity is obtained in a manner similar to Method I.

The compartmentation permitted is inferior to that required for Method I, but to compensate for this an automatic fire detection system is provided.

In Method III ships the use of combustible materials of all kinds such as untreated wood, veneers, ceilings, curtains, carpets, etc., is reduced as far as practicable. All exposed surfaces in corridors and stairway enclosures, and surfaces in concealed or inaccessible spaces are required to have low flame spread characteristics.

The basic principles of Part H are:—

(a) the division of the ship into main vertical zones by thermal and structural boundaries;

(b) the separation of accommodation spaces from the remainder of the ship by thermal and structural boundaries;

(c) the restricted use of combustible materials;

(d) the detection of any fire in the zone of origin;

(e) the containment and extinction of any fire in the space of origin;

(f) the protection of the means of escape and access for fire fighting;

(g) the ready availability of the fire extinguishing appliances.

In Part H all bulkheads within the main vertical zones are required to be Class 'A', 'B' or 'C' divisions. The precise standard of each division is determined from tables, in accordance with the designation of the adjacent spaces. In some cases a reduced standard is prescribed when the adjacent spaces are situated within a main vertical or horizontal zone which is protected by an automatic sprinkler system.

3.3.4 Openings in 'A' Class divisions

Any fire division is only as strong as its weakest point, it is therefore important to ensure that the fire integrity is maintained at such potential weaknesses as doors and the penetrations of trunks, electric cables, pipes, ducts and structural members such as beams and girders.

3.3.4.1 Doors

All doors and their frames and the means of securing them when closed are required to provide a resistance to fire as far as practicable, equivalent to that of the bulkhead in which they are situated. Doors may be single or double leaf and be either hinged or sliding types. They are usually of hollow box construction stiffened internally and packed with insulating material to give the required fire rating, viz. either A-15, A-30 or A-60. Hinged doors are provided with three strong hinges and a three-point securing mechanism operated by a handle which controls bolts on the three free sides.

Sliding doors are suspended from a rail by rollers and the bottom edge is restrained in a channel attached to the bulkhead. All doors must be capable of being opened from both sides by one person and be self-closing against a $3\frac{1}{2}$ degree adverse list. This latter requirement causes many difficulties, since it is almost impossible to design a mechanism whereby a door will close efficiently against such a list and yet avoid slamming when there is a list which assists closure. Slamming has been known to cause serious bodily injury. The doors are arranged to close rapidly under the action of a powerful spring, but the force of the final closure is reduced by a pneumatic damper or other suitable device.

Part H requires that all doors in 'A' Class divisions, except those that are normally closed, shall be capable of release from a control station, either simultaneously or in groups, and also from a position at the door. This usually takes the form of a steel plate on the back of the door and a corresponding electro-magnet on the wall. The door closes when the electric current is switched off either on the bridge or at the door, and the element is consequently demagnetised. Such arrangements, although not required by the 1960 Convention and therefore not mandatory, are often fitted at the owner's discretion (*see* Fig. 2).

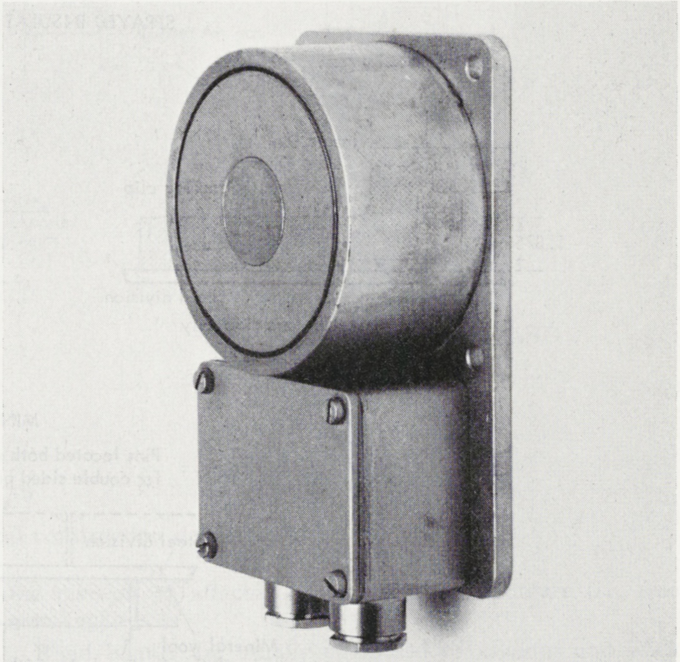


Fig. 2

Magnetic door retainer.

When double-leaf doors are fitted arrangements have to be provided to ensure that the doors close in the sequence necessary to effect closure.

The effectiveness of doors is required to be proved by a standard fire test and any door which is fitted should be constructed under survey to approved plans covered by a certificate of test by a reliable authority.

Watertight doors are accepted without insulation as doors in fire bulkheads.

When a ship is being surveyed, the surveyors should ensure that each door is a type which has been approved for the position. He should ensure that it will close automatically from the fully open position and also when it has been left open just sufficiently for an average person to pass through. He should test that it can be opened readily from both sides by one person and test the local and remote release mechanism, if the door is normally held open; hooks should not be fitted for this purpose.

3.3.4.2 **Ventilation ducts**

Where ventilation ducts pass through 'A' Class divisions the integrity of the division must be maintained by the provision of one or sometimes two dampers inside the duct irrespective of the size of the duct. The dampers are normally held open by a fusible link and if this link is fitted inside the duct only one damper is required, but if it is fitted outside the duct two dampers are required, i.e. one on each side of the division. The dampers are so designed that when the fusible link melts they will close under the action of a spring or counter weight.

In addition to automatic closure all dampers are arranged for manual closure from both sides of the division, and during surveys it is necessary to ensure that the dampers close when the fusible links are removed and that they are clearly marked on the duct and also on the access door in any ceiling or panelling which conceals them.

3.3.4.3 **Electric cables**

Where it is necessary to lead electrical cables through 'A' Class divisions, the penetration should be protected so that if the cables were burned away the fire could not pass through the division. This is achieved by fitting a suitably packed gland.

3.3.4.4 **Pipes**

Pipes which are always filled with water are not a great problem, but where pipes which are sometimes empty penetrate a division they must be insulated for a distance of 15 inches from the division on the side of the division on which the insulation is fitted.

3.3.5 **Insulation of 'A' Class divisions** (*see* Figs. 3a, 3b)

The insulating materials used for achieving the limitation of temperature rise on 'A' Class divisions should be non-combustible. They mainly consist of asbestos or mineral wool. Considerable difficulty is being experienced by manufacturers of asbestos based materials because of the incidence of asbestosis and cancers of the lung pleura and peritoneum among workers in the industry. There is therefore a great deal of activity in trying to produce an equivalent material.

There are four main classes:—

1. Sprayed asbestos, which is applied by machine directly to the surface of the division and secured in position by clips welded to the steel bulkhead, and bent over within the thickness of the coating. Care must be taken to ensure that the

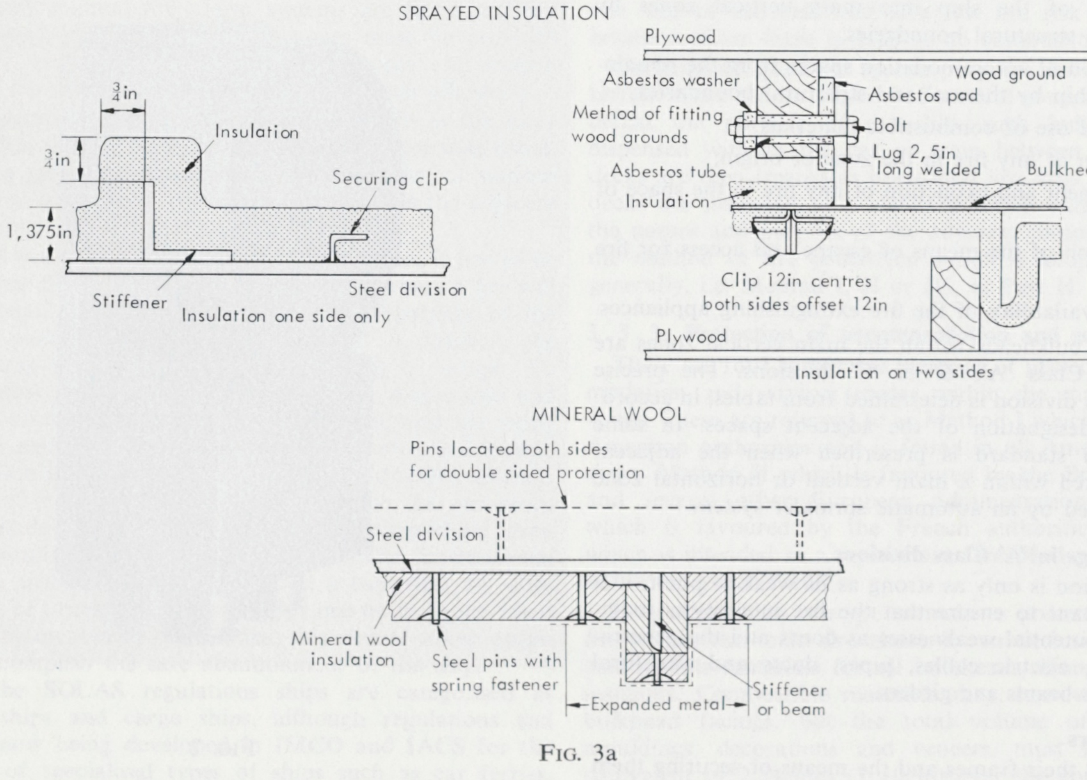


FIG. 3a

'A' class divisions, typical construction details.

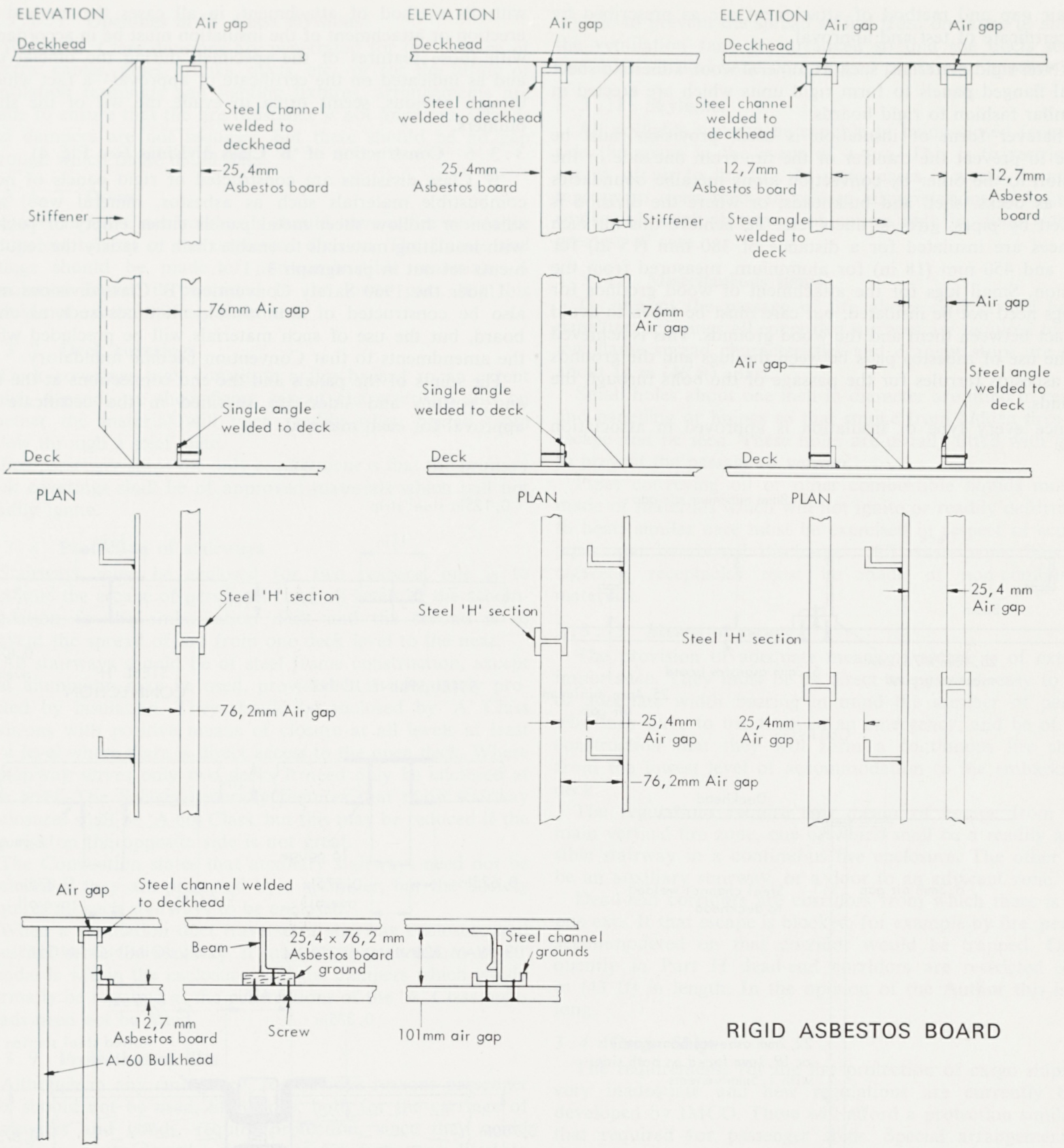


FIG. 3b

'A' class divisions, typical construction details.

required thickness and density is achieved all over the division.

2. Mineral wool slabs or mattresses which are cut to shape and forced over steel clips attached to the steelwork; wire netting is then spread over and washers placed over the clips; finally the clips are bent over.

3. Rigid boards either attached directly to the steel division or erected with a pre-determined gap and either attached to the division or attached to the adjacent structure (i.e. free standing).

Rigid boards are usually composed of asbestos and silica with a density of about 576 kg per sq. m (36 lb per cu. ft) and are produced with a satisfactory strength and with decorative laminate facings which allow them to perform the dual function of fire insulation and linings in the construction of living accommodation. Care must be taken to ensure that

the air gap and method of attachment are as prescribed by the certificate of test and approval.

4. Non-rigid materials, such as mineral wool, adhere to sheet metal flanged panels to form rigid units which are erected in a similar fashion to rigid boards.

Whatever form of insulation is used, provision must be made to prevent the transfer of the fire from one side of the division to the other by convection along metallic boundaries such as decks, shell and bulkheads, or where the division is pierced by pipes, girders, ducts, etc. To achieve this all such surfaces are insulated for a distance of 380 mm (15 in) for steel and 450 mm (18 in) for aluminium, measured from the division. Small lugs for the attachment of wood grounds for linings need not be insulated, but care must be taken to avoid contact between them and the wood grounds. This is achieved by the use of asbestos pads between the lugs and the grounds and asbestos ferrules for the passage of the bolts through the grounds.

Since every type of insulation is approved in association with its method of attachment, in all cases the method of erection or attachment of the insulation must be in accordance with those features of the specimen during the official test and as indicated on the certificate of approval—a fact which, though obvious, seems often to evade the wit of the shipbuilders.

3 . 3 . 6 **Construction of 'B' Class divisions** (*see* Fig. 4)

'B' Class divisions are constructed of rigid panels of non-combustible materials such as asbestos, mineral wool and silicon or hollow sheet metal panels either empty or packed with insulating materials to enable them to satisfy the requirements set out in paragraph 3 . 1 . 4.

Under the 1960 Safety Convention 'B' Class divisions may also be constructed of combustible materials such as chipboard, but the use of such materials will be precluded when the amendments to that Convention become mandatory.

The joints of the panels and the end connections at the top and bottom and sides are specified in the certificate of approval for each material.

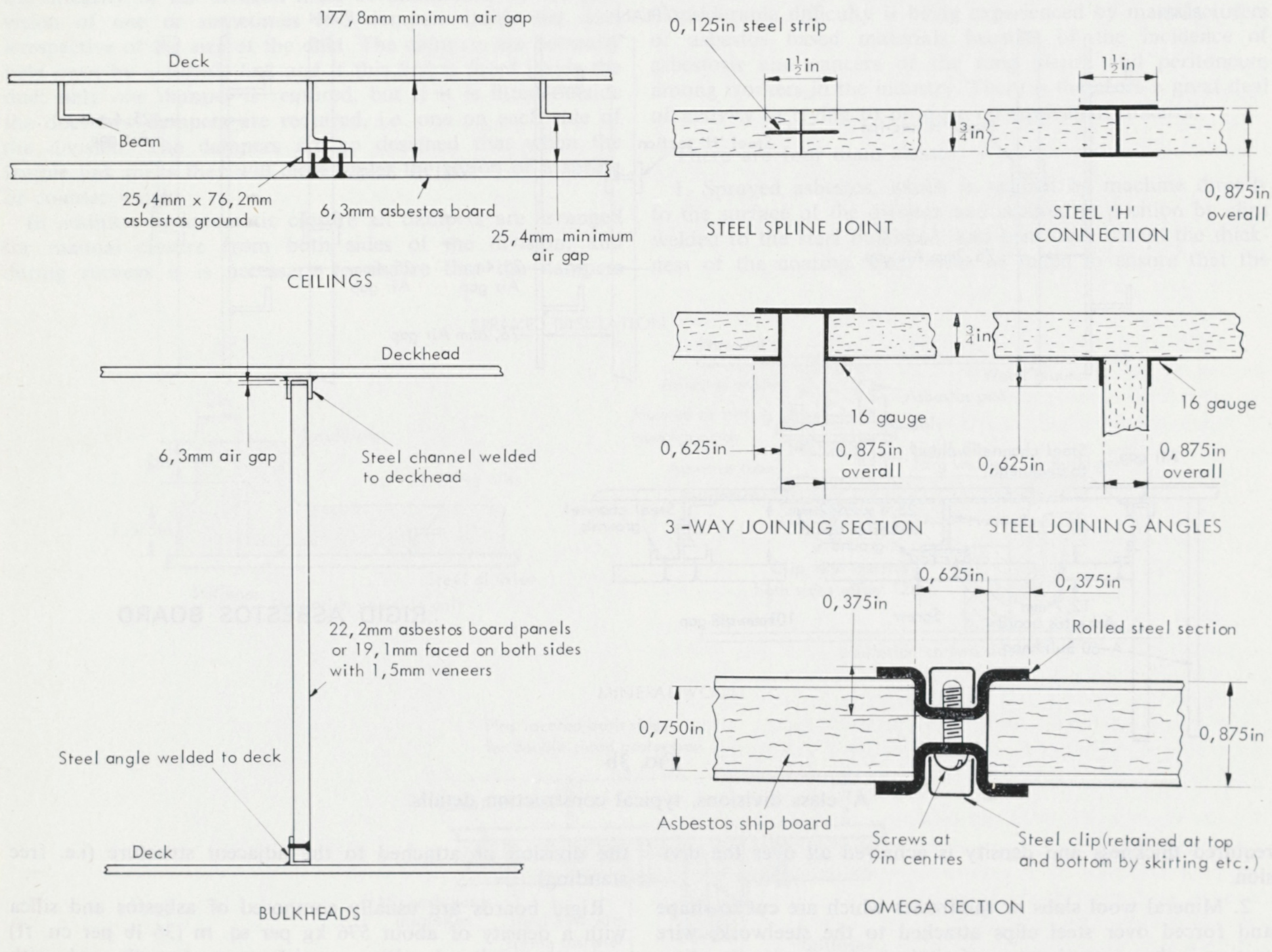


FIG. 4

'B' class divisions, typical construction details.

3 . 3 . 6 . 1 **Openings in 'B' Class divisions**

Where 'B' Class divisions are penetrated for the passage of electric cables, pipes, trunks, ducts, etc., or for the fitting of ventilation terminals and lighting fixtures, arrangements are made to ensure that the fire resistance is not impaired. Glands and dampers are not required, but there should be no gap through which flame could pass.

3 . 3 . 6 . 2 **Doors**

Doors in 'B' Class bulkheads should have a fire resistance equivalent to that of the unpierced division. The frames and fittings should be made of non-combustible materials. A ventilation louver is permitted in the lower part, but this should not exceed 0,05 sq. m in area.

3 . 3 . 7 **Deck coverings**

Deck coverings may constitute a fire hazard to an extent which depends on their flame spread characteristic and on whether the material will burn readily when heated from below through a steel plate.

For passenger ships the only requirement is that the primary deck coverings shall be of approved materials which will not readily ignite.

3 . 3 . 8 **Protection of stairways**

Stairways must be enclosed for two reasons, one is to facilitate the escape of personnel from all levels of the accommodation to the embarkation deck and the second is to prevent the spread of fire from one deck level to the next.

All stairways should be of steel frame construction, except that aluminium may be used, provided it is adequately protected by insulation. They should be enclosed by 'A' Class divisions with positive means of closure at all levels at least to a level where there is direct access to the open deck. Where a stairway serves only two decks it need only be enclosed at one level. The Society generally requires that main stairway enclosures shall be 'A-60' Class, but this may be reduced if the fire risk on the opposite side is not great.

The Convention states that auxiliary stairways need not be enclosed if they are protected by a sprinkler, but the Society requires all such stairways to be enclosed.

When a ventilation duct traverses a stairway enclosure and does not serve the stairway, it may be constructed to 'A-60' standards within the enclosure, and the dampers which would normally be required at the penetrations of the 'A' Class bulkheads need not be fitted.

3 . 3 . 9 **Protection of lifts**

Although in any emergency, for obvious reasons passenger lifts should not be used, lift trunks, both for the carriage of passengers and goods, require protection, since they could provide a route for the fire to travel from one level to another. If unprotected they could also produce a 'chimney effect' which would intensify the fire.

All lift trunks are therefore constructed of steel or other equivalent material and are usually insulated to 'A-60' standard. The doors are self-closing of equivalent fire resistance to the trunk.

3 . 3 . 10 **Ventilation systems**

Since one method of extinguishing a fire is to restrict the supply of oxygen, all the main inlets and outlets of ventilation systems must be capable of being closed from outside the space in the event of fire.

Also to prevent the spread of fire from one zone to another the ventilation fans are arranged so that the ducts serving one main vertical zone do not need to traverse another zone.

3 . 3 . 11 **Skylights**

All skylights have to be capable of being closed from outside the space in the event of a fire. This is to restrict the supply of air to the fire. In some cases it would be advantageous to open them to release accumulations of heat and smoke, although this must of course only be done with the greatest of care.

3 . 3 . 12 **Miscellaneous items**

To prevent the passage of fire above ceilings and behind panelling or linings all concealed surfaces are required to have low flame spread characteristics and draught stops are fitted about 14 m (46 ft) apart.

Small holes about one inch in diameter are fitted in ceilings and panelling or linings so that smoke from hidden fires may escape and be seen. These holes are usually fitted with grilles to prevent the passage of vermin.

Pipes conveying oil or other combustible liquids must be made of materials which will not ignite or readily deform due to heat; similar care must be exercised in respect of scupper pipes and overboard discharges. All waste-paper bins and cigarette receptacles must be made of non-combustible materials.

3 . 3 . 13 **Means of escape**

The provision of adequate means of escape is of extreme importance. They must be as direct as possible, easy to find, of adequate width bearing in mind the number of persons who may have to use them in an emergency, and be of such construction that they will form a continuous fire shelter from the lowest level of accommodation to the embarkation deck.

The regulations require two means of escape from each main vertical fire zone, one of which shall be a readily accessible stairway in a continuous fire enclosure. The other may be an auxiliary stairway, or a door to an adjacent zone.

Dead-end corridors are corridors from which there is only one exit. If that escape is blocked, for example by fire, persons accommodated on that corridor would be trapped. Consequently in Part H dead-end corridors are restricted to 13 m (43 ft) in length. In the opinion of the Author this is too long.

3 . 4 **Cargo Ships**

The requirements for the fire protection of cargo ships are very inadequate and new regulations are currently being developed by IMCO. These will afford a protection similar to that required for passenger ships. Special arrangements in respect of the fire protection of oil tankers have been adopted by IMCO and will be included in the 1974 Convention. Further reference is made to these arrangements in Section 6.

3 . 4 . 1 **Structure**

The hull, superstructure, structural bulkheads, decks and deckhouses are of steel or may be of aluminium provided this is suitably protected by insulation.

3 . 4 . 2 **Corridors** (*see* Fig. 5)

All corridor bulkheads in accommodation spaces are either of steel or 'B' Class divisions. Such 'B' Class divisions should extend from deck to deck or they may terminate at a con-

tinuous 'B' Class ceiling extending over the corridor to the shell or other steel boundary. All doors in 'B' Class bulkheads should have a fire resistance at least equivalent to that of the bulkhead in which they are fitted, and their frames and fastenings should be of non-combustible materials. Particular care should be taken during the survey of these divisions since the looseness of the wording in the 1960 Convention has led to a wide variation in the interpretation adopted by some national administrations, consequently an arrangement which was accepted by the Society in one ship may not necessarily be accepted in another.

3 . 4 . 3 **Deck coverings**

In accommodation spaces, coverings on decks forming the crown of machinery spaces are required to be of a type which will not readily ignite.

3 . 4 . 4 **Stairways**

The provision of open wooden stairways in ships, permitted even until quite recent time, has resulted in the escape route being cut off and many crew members losing their lives.

The 1960 Convention remedied this in part only, by requiring that interior stairways below the weather deck be of steel.

It is hoped that it will soon be required that all stairways shall be of steel and be protected by 'A' or 'B' Class enclosures as for passenger ships.

4 FIRE DETECTION

Most fires start from small beginnings and at that stage can readily be extinguished, but if undetected they can quickly grow to disastrous proportions.

If a fire is to be extinguished, it must be detected before it has reached proportions beyond the capability of the available fire extinguishing equipment.

Fires may be detected by personnel or automatically and the best arrangement is a combination of both.

All electrical fire detection systems should be connected to the main and emergency supply systems.

4 . 1 **Passenger ships**

All passenger ships are required to have a manual fire alarm system and to maintain an efficient fire patrol.

The manual alarm consists of the usual push button system and extends throughout the passenger and crew accommodation areas. It is connected to main and emergency electrical sources of supply. In many ships punch clocks are fitted at various points throughout the accommodation areas so that the patrol men may record the time when they pass each control point. The time interval between visits to any part of the accommodation should not exceed one hour.

In Method II ships a combined fire detector and sprinkler system is fitted and in Method III ships an automatic fire detector system is fitted. These systems are fitted throughout the accommodation and service areas and give an early warning to the bridge of any fire which occurs, including those which occur in cabins to which the fire patrol does not have access.

An approved fire alarm or detecting system is required to be provided in all cargo spaces which are not accessible to the fire patrols. These usually take the form of a smoke detection system which continually draws samples of the atmosphere from the cargo spaces into a cabinet on the bridge, where the presence of smoke will activate an alarm

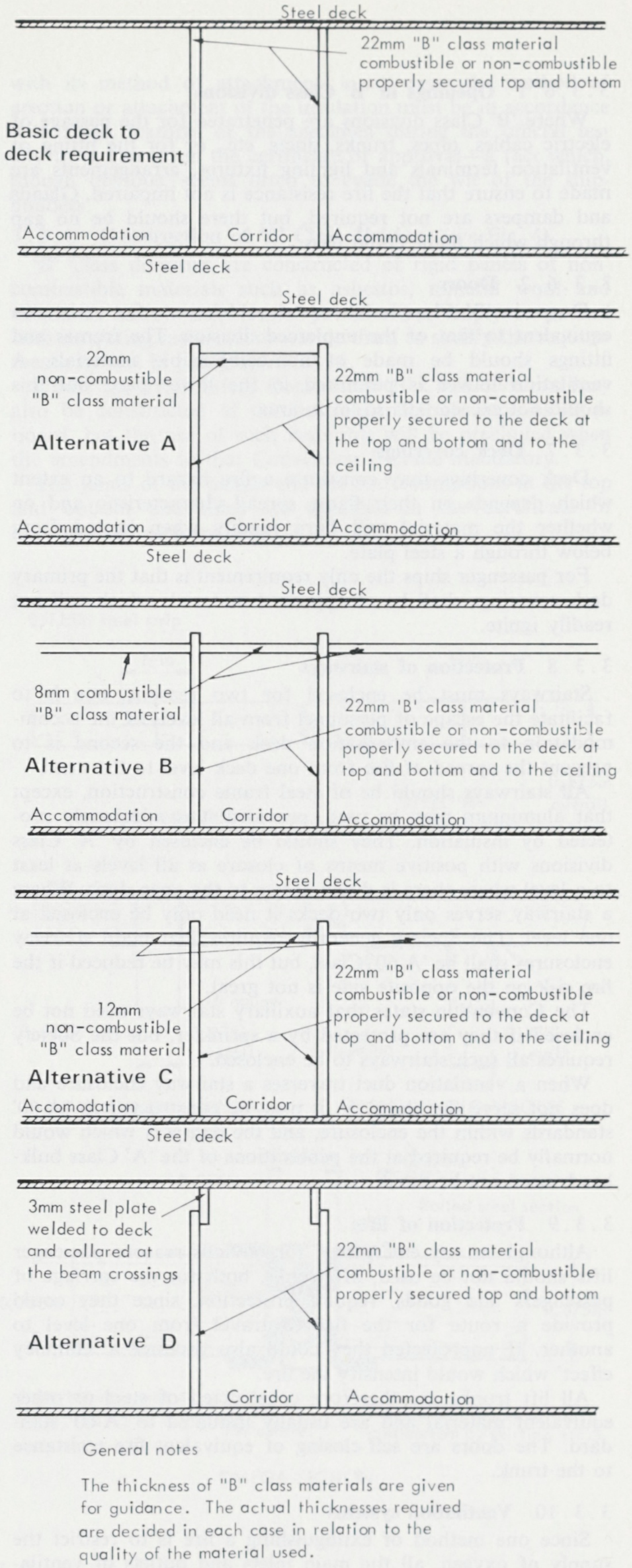


FIG. 5

Construction of 'B' class corridor bulkheads in cargo ships.

and indicate the source of the smoke. The pipes used for this purpose are normally those fitted for the supply of carbon dioxide fire smothering gas.

4 . 2 Machinery spaces

Where it is intended that the engine and/or boiler rooms will not be continuously manned at sea, an approved fire detecting system is required to be fitted. Such systems should be self-monitoring for faults and should initiate both audible and visual signals. The tone of the audible signal must differ from that of other alarm systems.

The type of detection system most commonly fitted in machinery spaces is the smoke detector, particularly in larger ships. Of the smoke detector type, the types depending on ionization chambers are the most popular, followed by photo-electric types. Some heat sensitive type heads have been fitted, but their use is mainly restricted to small engine rooms. In machinery spaces, detector systems have to function under the most complex conditions of atmosphere at sea and in ports with widely varying climatic conditions. The direction of air currents in such a space will vary greatly under these conditions, consequently it is difficult to achieve the optimum siting of the detector heads, especially the type which depends on sampling the air contents under fire conditions. To overcome this difficulty it is recommended that more than one type of detector head be fitted in any system and should include infra-red detector heads fitted in positions chosen to ensure an immediate response to flaming combustion. The current practice is to install about 10 per cent infra-red and about 90 per cent smoke detectors.

4 . 3 Types of detectors

4 . 3 . 1 Automatic sprinkler systems (*see* Fig. 6)

These systems are required to be fitted in all Method II ships. They are the most efficient method of protecting fire risks involving solid carbonaceous materials, since they combine an early warning device with an automatic water sprinkler system.

In a complex arrangement of accommodation spaces, such as is found in passenger vessels, the location of a fire in its early stages is often difficult and time consuming, even when its existence is known. The sprinkler system does much to overcome this since, while a fire is still well within the range of controllability, a warning is given and at the same time a powerful spray of water is directed into the fire, thus achieving either control or even extinction while the fire party are assembling, preparing their equipment and attempting to locate the seat of the fire.

The system consists of several sections comprising a number of sprinkler heads mounted on pipes, each section being connected through a section control valve to a sprinkler main which in turn is connected to a pressure tank and a pump, both of which must be situated in a position which is reasonably remote from any Category A machinery space and not in any space protected by the system. The entire system is charged with fresh water at a pressure of about 8,5 kg per cm^2 (120 lb per sq. in) by a tank containing about 5000 litres (1000 gallons) of fresh water maintained under pressure by a small air compressor. It is also connected to an independent pump with its own sea suction.

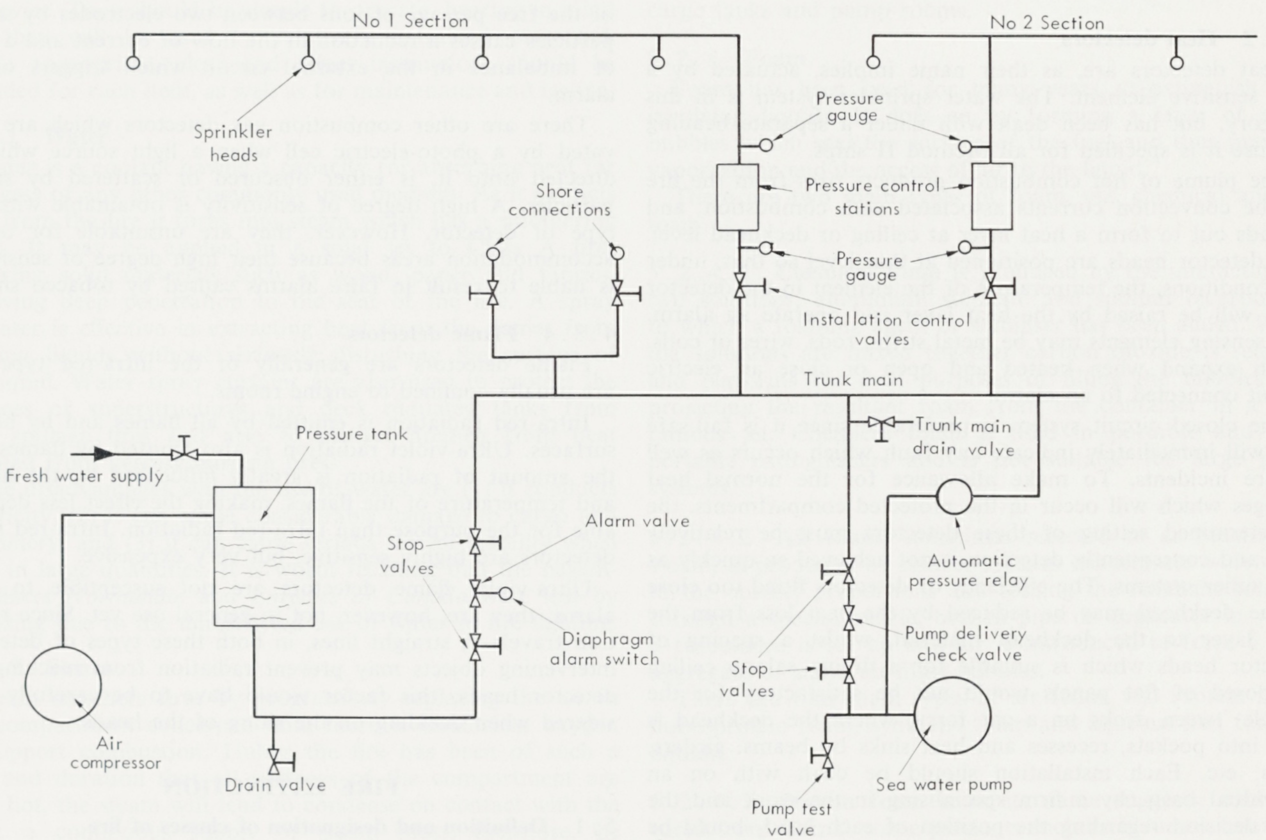


FIG. 6

The Grinnel automatic sprinkler and fire alarm system.

The sprinkler heads consist of a nozzle sealed by a quartzoid bulb containing a liquid with a coefficient of expansion which will cause the bulb to burst at a predetermined temperature. This releases the water in the system and the resultant pressure drop starts the sea water pump and thus ensures a continuous spray of salt water until the pump is stopped. At the same time the drop in pressure in the system causes an alarm to sound on the bridge and indicates on a board, the zone in which the ruptured sprinkler head or heads are situated. Sprinkler sections are arranged to coincide with the structural main fire zones. In general they should not contain more than 200 heads in one section, nor serve more than two deck levels. The section valves are provided with a valve for testing the automatic alarm. A test cock is also provided at the pump discharge by which the automatic cut-in of the pump can be tested.

The sprinkler heads are spaced not more than 4 m (13 ft) apart and 2 m (6 ft 6 in) from any bulkhead or part of the ship's side which forms a boundary of the protected space. The application rate is 5 litres per minute per sq. m (0·1 gal/min/sq. ft) which must be based on the deckhead area where this exceeds the deck area.

The system described above is the Grinnel system which has proved its worth over many years. There are others, one of which relies on high pressures and sprinklers designed to produce very fine droplets of water. These systems are considered to be less effective than the Grinnel system, particularly in large, open compartments, or those with high deckheads. They have, however, been accepted by at least one national authority.

4.3.2 Heat detectors

Heat detectors are, as their name implies, actuated by a heat sensitive element. The water sprinkler system is in this category, but has been dealt with under a separate heading because it is specified for all Method II ships.

The plume of hot combustion products rises from the fire on the convection currents associated with combustion, and spreads out to form a heat layer at ceiling or deckhead level. The detector heads are positioned at that level so that, under fire conditions, the temperature of the element in the detector head will be raised by the heat layer and operate an alarm. The sensing elements may be metal strips, rods, wires or coils, which expand when heated and open or close an electric circuit connected to an alarm.

The closed circuit system is preferable since it is fail-safe and will immediately indicate any fault which occurs as well as fire incidents. To make allowance for the normal heat changes which will occur in the protected compartments, the predetermined setting of these detectors must be relatively high and consequently detection is not achieved so quickly as with other systems. The efficiency of detectors fitted too close to the deckhead may be reduced by the heat loss from the heat layer to the deckhead material, whilst a spacing of detector heads which is suitable for a dining saloon ceiling composed of flat panels would not be satisfactory for the vehicle 'tween decks on a car ferry, where the deckhead is split into pockets, recesses and heat sinks by beams, girders, ducts, etc. Each installation should be dealt with on an individual basis, by a firm specialising in the work and the final decision regarding the position of each head should be decided at the ship.

In situations where a fire will immediately generate a great deal of heat, the delayed action otherwise inherent in this type of detector is of little importance and advantage can be taken of its robustness, simplicity of action and reduced cost.

There are three categories of heat detector, viz.:—

1. Fixed temperature detector which operates when the air temperature rises above a pre-set level.
2. Rate of rise detectors which operate when the rate of rise of the air temperature exceeds a pre-set rate.
3. Combined fixed temperature and rate of rise of temperature.

The disadvantage of type 1 lies in its susceptibility to false alarm unless the setting is relatively high, therefore in practice it is slow acting.

The disadvantage of type 2 lies in its inability to detect a slow developing fire.

Type 3 is therefore preferable since in it the disadvantages of types 1 and 2 are compensated.

Heat detectors with solder elements are not recommended since they cannot be tested and they can be affected by the combined effects of heat (other than from a fire) and vibrations.

4.3.3 Combustion gas detectors

The combustion gas detector is so called because it responds to large particles which enter the detector head. It utilises the effects of products of combustion on a minute current flowing across an open ionization chamber in which air is ionized by radiation from a radioactive source. Obstruction of the free passage of ions between two electrodes by smoke particles causes a reduction in the flow of current and a state of imbalance in the external circuit which triggers off an alarm.

There are other combustion gas detectors which are activated by a photo-electric cell when a light source which is directed onto it, is either obscured or scattered by smoke particles. A high degree of sensitivity is obtainable with this type of detector. However, they are unsuitable for use in accommodation areas because their high degree of sensitivity is liable to result in false alarms caused by tobacco smoke.

4.3.4 Flame detectors

Flame detectors are generally of the infra-red type and are usually confined to engine rooms.

Infra-red radiation is emitted by all flames and by heated surfaces. Ultra-violet radiation is also emitted by flames, but the amount of radiation is greatly influenced by the nature and temperature of the flames, making the effect less dependable for the purpose than infra-red radiation. Infra-red flame detectors are highly sensitive, but very expensive.

Ultra-violet flame detectors are not susceptible to false alarm; they are, however, not in general use yet. Since radiation travels in straight lines, in both these types of detectors intervening objects may prevent radiation from reaching the detector heads; this factor would have to be carefully considered when deciding on the siting of the heads.

5 FIRE EXTINCTION

5.1 Definition and designation of classes of fire

The British Standards Institution has set forth the following designations for the purpose of classifying fires of different

natures, in order to simplify spoken and written reference to them: —

Class A These are fires involving solid materials, usually of an organic nature in which combustion normally takes place with the formation of glowing embers.

Class B These are fires involving liquids or liquefiable solids.

Class C These are fires involving gases.

Class D These are fires involving metals.

5.2 Fire extinguishing agents

The substances used for extinguishing fires on board ships are (1) water; (2) steam; (3) carbon dioxide; (4) foam (referred to in IMCO documents as froth); (5) dry powders; (6) inert gas; (7) nitrogen; (8) halogen based vaporizing liquids.

The choice of fire extinguishing agent for a particular hazard is very important since some will be more efficient than others, some are conductors of electricity and would therefore be dangerous to personnel, some are toxic and others may do more damage than the fire itself. Some would not extinguish the fire whilst others would even exacerbate the incident, e.g. when a jet of water is applied to the surface of an oil fire the burning oil is splashed about and spreads the fire, and water applied to burning magnesium swarf increases the rate of combustion and produces small explosions which spread the fire.

All fire fighting equipment should be robust, reliable and not subject to rapid deterioration in a marine environment in all climates which the ship will be likely to encounter during its service. They should be simple to operate, bearing in mind that they will be used by relatively untrained personnel. Where appropriate, clear and direct instructions should be provided for each item, as well as for maintenance and testing.

5.2.1 Water

Water is a coolant having a capacity for absorbing heat far in excess of any other commonly used medium. As it extracts heat from the fire it turns into steam which has a smothering effect. It may be applied in a solid jet to Class A fires involving solid materials such as wood, paper and fabrics, achieving deep penetration to the seat of the fire. A spray of water is effective in extracting heat from the flames from burning liquids without seriously disturbing the surface of the liquid. Water spray curtains are also used to protect the surfaces of superstructures and deck mounted tanks from deck spillage fires and also to protect firemen from heat radiated from fiercely burning fires.

The disadvantages with the use of water are (1) it conducts electricity, (2) it can cause considerable damage to cargo and machinery, and (3) it can cause serious loss of stability when used in large quantities. It is worth recalling that the passenger liners *Normandie* and *Empress of Canada* were lost by capsizing due to the unrestricted use of water in fire fighting.

5.2.2 Steam

Steam smothers fires by progressively replacing the air in the compartment concerned until there is insufficient oxygen to support combustion. Unless the fire has been of such a size and duration that all surfaces of the compartment are very hot, the steam will tend to condense on contact with the steel; a continuous supply of steam must, therefore, be supplied in order to maintain the process until complete extinction has been achieved. Since the density of steam is less than that of air, it tends to rise to the top of the compartment and must therefore be injected at the lower levels.

Steam is not a very effective extinguishing agent and is rarely fitted in new ships although it is still to be found in existing vessels. Steps are now being taken to preclude its use.

5.2.3 Carbon dioxide

Carbon dioxide is a very effective extinguishing agent which has been used for many years. Extinction is achieved by diluting the oxygen content of the atmosphere in the compartment from normal 21 per cent to a level which is insufficient to support combustion; for most substances this will be achieved at concentrations of 12 to 16 per cent, but for smouldering solid combustible materials a reduction to 5 per cent may be necessary to accomplish complete extinction.

Carbon dioxide has a number of advantages: —

(1) It is non-corrosive. (2) It does not conduct electricity. (3) It leaves no residue. (4) It is fairly easy to store and is not subject to deterioration in quality with age. (5) It is always immediately available, even in the dead ship condition.

Its disadvantages are (1) It is highly asphyxiating and slightly toxic, a concentration of about 9 per cent will produce unconsciousness within a few minutes; (2) It has little cooling effect and there is consequently a danger of re-ignition if air is readmitted to the compartment too quickly; (3) When discharged from a high pressure system particles of solid carbon dioxide are often present and can generate sufficient static electricity to produce a spark which will ignite flammable atmospheres such as may be found in ships, for this reason carbon dioxide is unsuitable as an inerting medium in cargo tanks and pump rooms.

5.2.4 Foam

Foam has been used for many years to extinguish fires involving liquids. It does so by forming a layer of small bubbles which seal the surface of the fuel and thus prevents vaporization and the access of air to the liquid.

There are two main types of foam, viz. chemical and air foam.

5.2.4.1 **Chemical foam** is produced by the interaction of two solutions, aluminium sulphate and sodium bicarbonate, to which a foaming agent or stabiliser has been added. When the solutions are mixed together carbon dioxide is released and performs the dual purposes of filling the bubbles and projecting the resultant foam from the container in a continuous jet. Chemical foam is used in portable and non-portable extinguishers and is not suitable for large piped systems.

5.2.4.2 **Air foam,** sometimes referred to as Mechanical Foam, is produced by mixing a foam concentrate with water in the correct proportions and forcing the resultant solution through a special nozzle, branch pipe or applicator in which a turbulence is set up and air is introduced to form a fluid aggregate of small air-filled bubbles.

There are four main types of air foam, viz. Protein foam, fluoroprotein foam, synthetic foam and aqueous film forming liquids.

5.2.4.3 **Protein foam** is as its name suggests, manufactured from animal waste products such as blood or hoof and horn meal, with a stabiliser added; it is cream in colour and has an unpleasant smell. The foam solution is usually a

mixture of 3 per cent foam concentrate to 97 per cent water and has an expansion ratio of about eight to one.

5.2.4.4 **Fluoroprotein foam** is a normal protein foam to which a fluorine based compound has been added. It is vastly superior to normal protein foams and also much more expensive. When foam is projected onto a burning liquid it submerges before rising to float on the surface. As it does so the bubbles become contaminated with the fuel, so that sometimes the foam itself burns. This does not happen with fluoroprotein foam because the fuel does not adhere to it.

5.2.4.5 The foaming agent used in producing Synthetic Foam is similar to that from which hair shampoo and washing-up liquids are manufactured. The foam solution consists of 5 per cent concentrate to 95 per cent water. The resultant foam is white and is less persistent than protein foams. It is superior to normal foam, but less efficient than fluoroprotein foam.

Synthetic foams are very flexible and can be produced as Low Expansion Foam at expansion ratios up to 12 to 1, Medium Expansion Foam at ratios up to 150 to 1, and High Expansion Foam at ratios up to 1000 to 1.

Low expansion foam can be applied by monitors or hand held hoses and applicators. It can be projected by these means over considerable distances, although the greater the distance the greater will be the area over which the foam is scattered.

Medium expansion foam is only applied through hand held hoses and can only be projected over a range of about 15 m. This means that the operators must wear breathing apparatus and protective clothing and even then there is considerable danger involved in approaching a large fire so closely. It is more suitable for use on fires in enclosed spaces such as tanks than for deck spillage fires.

High expansion foam cannot be projected at all, but is led through ducts or allowed to fall freely. It is used to entirely fill the compartment in which a fire is situated. When applied to a fire, part of the foam is flashed to steam, producing a mixture of steam and air, the oxygen content of the mixture being too low to support combustion. High expansion foam has considerable cooling properties, and is an excellent shield against radiant heat, thus preventing the spread of a fire. It is effective against fires involving low flash point liquids which do not readily dissolve in water.

High expansion foam is produced by spraying an aqueous foam solution uniformly onto a fine mesh nylon screen, air is then driven through the screen by a large fan to form huge masses of bubbles at the rate of from 1200 to 54 000 cu. ft of foam per minute depending on the size of the unit.

5.2.4.6 **Aqueous film-forming foam**

The product in this category which is often referred to in relation to flammable liquid fires is a proprietary brand called 'Light Water'.

The concentrate is based on fluorochemical wetting agents and has the ability to make water float on flammable liquids which have a lower density than water. It is mixed with water in the proportion of 6 per cent to 94 per cent and driven through conventional air foam-making equipment to form a foam with an expansion ratio of 8–10 to 1 which is applied to the surface of the burning liquid. The foam spreads rapidly over the surface and water drains from it and floats over the surface to provide a vapour seal. This aqueous film forming action enhances extinction and prevents flash-back, even when the foam blanket is ruptured.

This is a most efficient extinguishing agent, but it is very expensive.

5.2.4.7 **Alcohol foam**

Normal foam is unsuitable for extinguishing fires involving water-miscible liquids such as some alcohols (e.g. methyl, ethyl, isopropyl), esters (e.g. ethyl acetate), ketones (e.g. isopropyl ether, diethyl ether), etc., which absorb water from the foam and thus break down the bubble walls. For this purpose special foams are produced known as Alcohol Foams; these are also referred to as All Purpose Foams, because they can also be used on ordinary hydrocarbon liquid fires, although it should be noted that they are not as suitable for that purpose as protein foams and may require an increased application rate to achieve extinction.

All foam concentrates intended for marine fire fighting must be suitable for use with sea water.

It is not sufficient for a foam application to extinguish the fire, it must also be capable of maintaining an effective seal over the surface of the fuel, so that if re-ignition does occur at any point, the fire will not spread rapidly to engulf the entire area. This characteristic is known as burn-back. Fluoroprotein foam has a good burn-back characteristic.

5.2.5 **Dry powders**

Dry powders (also known as dry chemicals) are flame inhibitors. The exact chemistry of their extinguishing action is not fully known; cooling of the flames occurs to a limited extent due to the low temperature of the nitrogen gas propellent, and radiation shielding by the powder cloud has some effect, but the principle action consists of interference with the chain reaction of the process of combustion.

The powder is only effective whilst in atmospheric suspension in the flame zone and if, when the fire has been extinguished and the powder has settled, the fuel is above its auto-ignition temperature, re-ignition or flash-back will occur. Re-ignition may be prevented by cooling the fuel and the adjacent structure with water spray or sealing the surface of the fuel with a layer of foam which must of course be one that is compatible with the powder. The commonest powder used is sodium bicarbonate; there are several proprietary brands which are more effective, but also, unfortunately, more expensive.

Powder is subject to packing due to vibration, and clogging due to humidity and this is prevented by the addition of a metallic stearate.

The advantages of dry powder are:—

(1) It is effective with fires in most substances;

(2) It is a non-conductor of electricity;

(3) It is non-toxic;

(4) It is non-corrosive.

Its disadvantages are:—

(1) It has no cooling effect;

(2) It leaves a residue.

5.2.6 **Inert gas**

Carbon dioxide and nitrogen are, of course, inert gases, but are dealt with under separate headings in this section. When we talk about inert gas in marine fire protection we are usually referring to boiler flue gas or gas produced by burning diesel fuel. Both these systems are more usually used in oil tankers for inerting the atmosphere of the cargo tanks in order to prevent explosions, but they are also accepted for

fire smothering purposes in dry cargo holds. The gas produced consists of about 14 per cent carbon dioxide, about 1 per cent oxygen and about 85 per cent nitrogen, although there are other trace elements present.

The fire extinguishing process is one of smothering by replacing the air in the compartment. It has no cooling effect, therefore, if re-ignition is to be avoided, time must be allowed for extinction to be assured and for the metal surfaces to cool, before dissipating the gas and allowing air to enter. Inert gas is asphyxiating and toxic and since dangerous oxides of nitrogen (often referred to as NO_x) may be present, care must be taken before entering a compartment, that it has been effectively ventilated and that no pockets of NO_x remain.

5.2.7 Nitrogen

Nitrogen may be used as a fire smothering agent or as a fire or explosion preventive agent where other types of inert gas are unacceptable to the shipper, because they would contaminate the cargo. It is a gas with a density slightly less than that of air. The concentration required to extinguish a fire is higher than that required for CO_2.

The general use of nitrogen as an extinguishing agent has been limited by its low critical temperature, minus 147°C (232°F).

5.2.8 Halogen based vaporizing liquids

There are a number of halogen derivates of hydrocarbons such as methane and ethane which are exceptionally good fire extinguishing agents. Some of these are carbon tetrachloride (C.T.C.); 1.1.1 trichloroethane (methyl chloroform); chloromethane (C.B.); bromochlorodifluormethane (B.C.F. or Halon 1211); bromotrifluoromethane (B.T.M. or Halon 1301). Unfortunately all are toxic and when applied to fires they decompose, forming mainly acid gases with the possibility also of small amounts of chlorine, bromine or fluorine. These decomposition products are more toxic than the liquids themselves. For this reason authorities have been reluctant to accept these agents for use on board ships. However, B.C.F. and B.T.M. are less toxic than the others and are now cautiously being accepted for marine use.

The extinguishing action of these liquids is greater than can be accounted for by dilution of the oxygen of the atmosphere by their vapours and is primarily by chemical interference with the chain reaction of the combustion process (similar to dry powder).

5.3 Fire extinguishing systems and appliances

5.3.1 The washdeck and fire main

5.3.1.1 General

The availability of an unlimited supply of water is the one advantage the marine fire fighter has over his land-based counterpart. His disadvantage is the limited quantity of fire fighting agents which can be carried without gravely affecting the economic running of the ship. The fire main is therefore the backbone of all the fire fighting services on a ship; by it water is supplied to hydrants which are so situated that using the available hoses and nozzles, two powerful jets of water may be directed on any part of the ship including the cargo holds when empty.

5.3.1.2 Fire pumps

Water is supplied by three independent pumps in a passenger ship and two in a cargo ship, although these requirements are reduced in smaller vessels of both types. The pumps have to be so arranged that a fire in any one compartment will not put all the fire pumps out of action. In passenger ships this is easily achieved since they generally have more than one engine room, but in cargo ships it is generally necessary to provide an emergency fire pump.

The main fire pumps may also be used for other water services such as bilge and ballast and general service, but they should not normally be used for pumping oil. They may be used for occasional duty for pumping oil provided a suitable change over system is fitted such as inter-locked valves or a portable section of piping, to ensure that oil cannot be inadvertently discharged into the fire main.

The emergency fire pump should be electrically or diesel powered and both it and its power or fuel supply should be so situated that they will not readily be affected by fire or smoke from the compartment containing the main fire pumps. The pump should generally be fitted in a well ventilated position readily accessible from the open deck in all weather conditions so that it can be brought expeditiously into operation when required. It should have an independent sea suction and be capable of operating efficiently at the lightest sea-going draught likely to be encountered during service. The sea suction valve should be capable of being controlled from a readily accessible position. If the emergency fire pump is electrically operated it must be powered by the emergency generator and the supply cables should be kept clear of surfaces, such as the machinery casings, which may become hot when there is a fire in the compartment containing the main fire pumps.

When a diesel driven pump is provided its air inlets should be so arranged as to minimise the risk of engine failure due to ingress of smoke or water.

In ships with engines aft it is sometimes impracticable to fit the emergency fire pump remotely from the main fire pump compartment. In such cases they may be located in compartments having common boundaries provided these boundaries are constructed to A-60 standards.

In general, direct access from a main machinery space to an emergency fire pump compartment is not allowed, but where it is specifically requested, such access may be arranged provided an air lock is also arranged, each of the two doors being self-closing.

Emergency fire pumps should be capable of being readily started from cold. When they are electrically driven the emergency generator should be capable of being started manually or by a manually operated starting device such as an inertia starter.

Compressed air starting is accepted if a manually operated compressor or a manually started compressor unit is provided; where the sole means of starting is a manually operated compressor a small air bottle capable of providing one start of the emergency fire pump should be fitted in addition to the main air receiver. Where the sole means of starting comprises electric batteries, two sets of batteries should be provided each capable of six starts, at least one of them should be on constant trickle charge and a hand started battery charger should be fitted. When a diesel driven emergency fire pump is fitted a service fuel tank should be provided having a capacity sufficient for the pump to be run at the required output for at least 12 hours.

Fire pumps must not be situated in pump rooms, cofferdams and other spaces liable to contain explosive vapours or

in spaces immediately adjacent to cargo oil or slop tanks. Care must be taken to ensure that the doors and ventilator openings to the compartment and any air inlets of the pump are so situated in relation to cargo tank openings such as vent pipes and P.V. valves, as to preclude the possibility of drawing dangerous vapours into the compartment.

When a fire pump is situated in a compartment forward of the cargo tanks of an oil tanker and below the level of the cargo tank deck and having access onto that deck, it may be possible in certain wind conditions for dangerous vapours to enter the compartment and cause an explosion. In such cases the opening onto the cargo tank deck should be fitted with self-closing air lock doors and the compartment should be mechanically ventilated with the air inlet situated remote from any dangerous zone or space.

In deep draught ships, difficulty is sometimes experienced in achieving an adequate delivery rate from the emergency fire pump into the fire main. This is often overcome by fitting a hydraulic pump at a low level in the forward end of the ship, driven by a diesel pump situated at deck level. The hydraulic pump raises the water to the diesel pump which then delivers it into the fire main at the required rate.

5.3.1.3 **Piping**

The risers from the main fire pumps should be connected to the deck main outside the engine room and they should have screw down valves fitted in readily accessible positions outside the compartments containing the pumps so that when that part of the system is damaged it can be isolated and the use of the remaining part of the system be maintained (*see* Fig. 7). The deck main should not be run through the machinery spaces. Relief valves should be provided if the fire pumps are capable of developing a pressure greater than the design pressure of the pipes, hydrants and hoses. If the ship is intended for service in places where freezing may be expected, provision should be made for draining the deck main.

Materials readily rendered ineffective by heat should not be used for the fire main, but pipe couplings containing rubber, such as the Sterling Dresser type, are accepted for use generally. Unless there is a hose provided for each hydrant in the ship, there must be complete interchangeability of the hose couplings and nozzles, although this does not preclude the provision of a small bore water system in the accommodation areas.

In oil tankers and ships intended for the carriage of dangerous liquid chemicals in bulk, stop valves should be provided at intervals along the deck main so that in the event of the main being ruptured by an explosion the damaged section may be isolated and leave the remaining section available for fighting residual fires.

The fire main must be available for fire fighting at all times, therefore it must not have any permanent connection to any service demanding large supplies of water. It is, how-

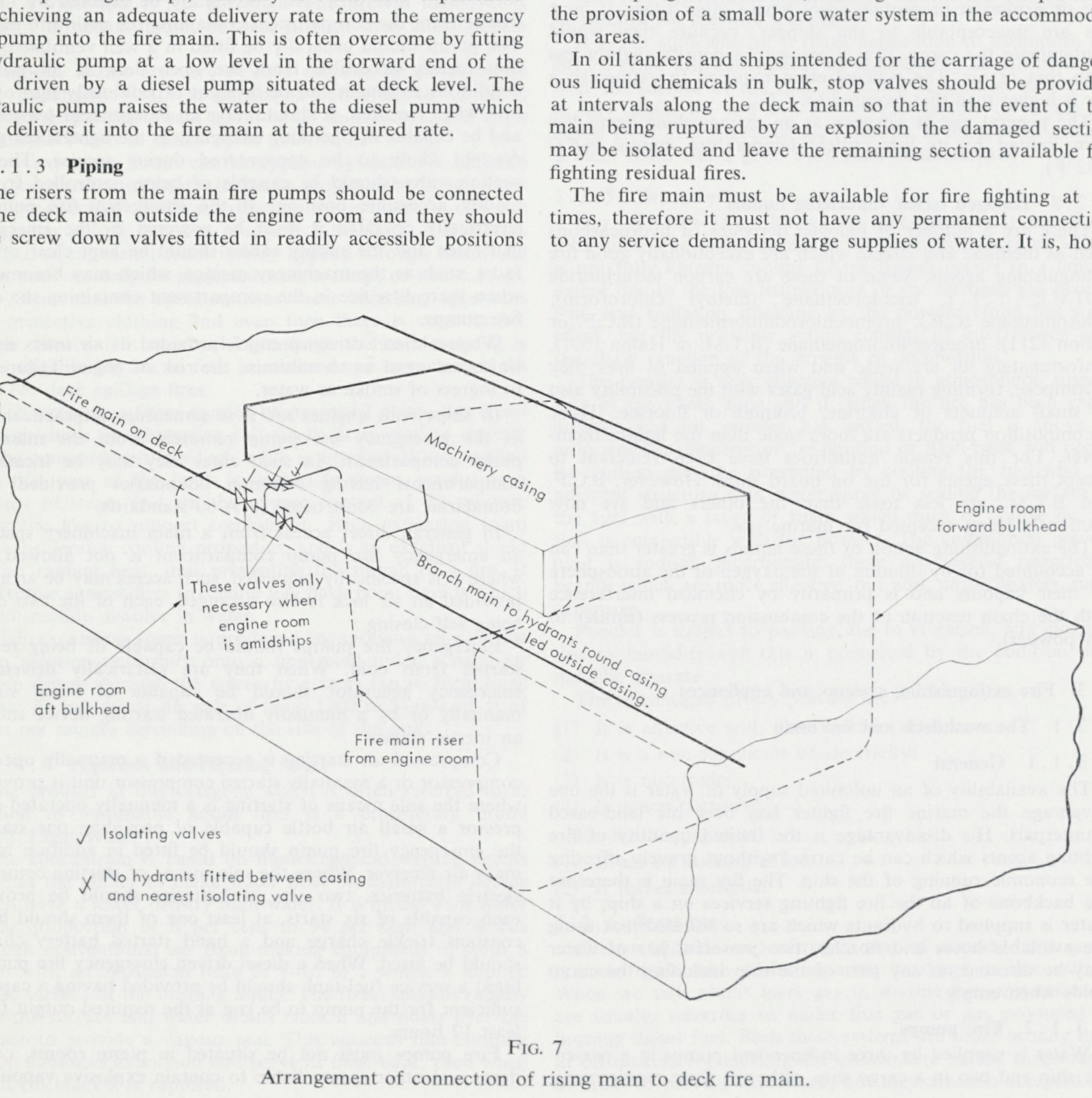


FIG. 7
Arrangement of connection of rising main to deck fire main.

ever, permissible to fit branches for such low demand services as hawsepipe cleaning and forepeak and chain locker bilge eductors.

5.3.1.4 **Hoses and nozzles**

Hoses may be made of a number of materials. Canvas hose used to be almost universal and has the advantage of protection against heat by water seeping through its weave; however, it also has the disadvantage of being subject to mildew, especially if it is not properly dried after use. There are now better hoses available which are constructed from synthetic woven textiles, lined with rubber and sometimes coated with PVC. These hoses are very strong and are not affected by oils, most chemicals, mildew and the extremes of climate.

Hoses of 64 mm ($2\frac{1}{2}$ in) diameter used to be considered standard, but lined hoses of $1\frac{3}{4}$ in and $1\frac{1}{2}$ in diameter are now considered preferable. These smaller diameter hoses produce an identical jet to that from a $2\frac{1}{2}$ in diameter hose using the same nozzle, but are much more manœuvreable since the column of water in them is lighter.

Great care must be taken with the securing of the coupling and nozzles; this may be effected with wire tightly wound on and secured, or metal rings clamped on by a special machine, or jubilee clips.

Jet nozzles are most effective for use against Class A fires, but spray nozzles must be used with Class B fires. Combined spray and jet nozzles are widely used, but the best type also has a shut-off valve. This latter type is particularly useful for oil spillage fires, because once the fire has been extinguished the water can be stopped at the nozzle and the hose kept charged; the water can then quickly be turned on again by the operator should re-ignition occur (*see* Fig. 8).

Nozzles are generally made of brass or aluminium alloy, but there are now approved nozzles made of very tough plastics. It should be noted that aluminium nozzles should not be used in tankers and other ships where there is a danger of explosive vapours being present, because of the danger of creating an incendive spark.

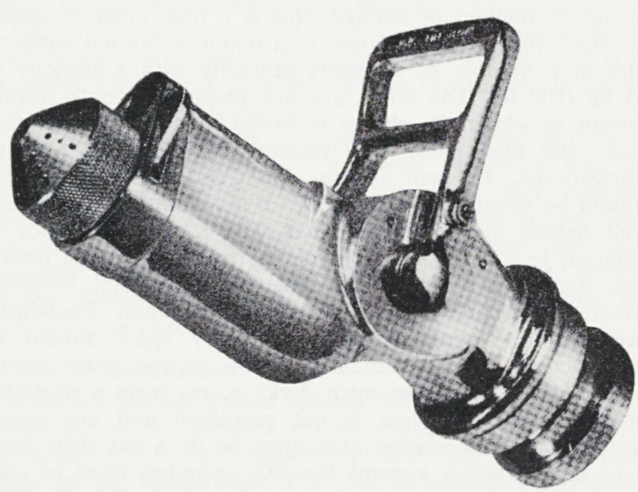


FIG. 8

Combined jet/spray nozzle with shut-off valve.

An international shore connection is provided in each ship to enable the deck main to be supplied with water from shore when the ship is in port.

5.3.2 **Water spray systems**

5.3.2.1 **General**

Water spray systems are used in machinery spaces, cargo pump rooms and vehicle 'tween decks. They are aso used as fire preventive measures over deck mounted tanks and the cargo loading positions on liquefied gas carriers, and on the poop fronts of oil tankers.

The fire-extinguishing efficiency of water spray systems depends on the diameter of the spray head orifices, the discharge pressure and droplet size, the impingement angle and cone angle of the spray, the momentum of the spray and therefore the likelihood of water in quantities reaching the surface of the burning liquid against the updraught of the flames and, which is very important, the simultaneous total coverage of the flammable surface.

Each fire produces its own problems. In machinery spaces tank top obstructions may prevent the spray from reaching the burning surface. Boiler fronts, oil fuel units and transfer pumps, oil heaters and purifiers are special risk items which must be given local protection, perhaps at a higher water rate by using spray heads of an appropriate design.

Considerable reliance is placed on the expert advice based on experience and tests, of the equipment manufacturers for ensuring that the system provides ample coverage for all the risks involved.

5.3.2.2 **Machinery spaces and cargo pump rooms**

The principal features of an installation for the protection of a machinery space are a water main with distribution branches fitted with spray heads spaced to cover all areas of risk. The installation may be divided into sections each covering a specific risk area such as the tank top, boiler flats, tank flat, etc., but in all cases the entire system must be capable of efficient simultaneous operation. The valves for controlling the system and the pump supplying the water, must be situated in positions not likely to be affected by a fire in the compartment served.

Water is supplied by a pump specially provided for the purpose and automatically started by a pressure drop in the system when any section valve is opened. Pressure in the system is normally maintained between the pump and the valve chest by a small hydraulic cylinder under air pressure.

The system must be capable of providing an effective average distribution of water of at least 5 litres per sq. m (0·1 gallons per sq. ft) per minute in the space protected.

The fuel or power supply for the pump must be entirely independent of the protected compartment.

5.3.2.3 **Vehicle 'tween decks**

The extinction of fires in the vehicle spaces of passenger/car ferries, of which there is an increasing number all over the world, presents a number of problems, especially when the passengers have access to the space. Usually the space extends for practically the entire length of the ship, the fire may, therefore, extend over that area. To use CO_2 would demand a large quantity of gas and that would present storage problems; in any case CO_2 being asphyxiating, could not be used in a space to which passengers have access. Low expansion foam would not be suitable. High expansion foam would

be suitable, but it would demand an extremely high delivery rate to be effective. The only viable alternative at present is water spray and even this entails a serious stability problem due to the possibility of the collection of water with a large free surface in the upper levels of the ship.

A water spray system on a vehicle deck requires pipes ranged along the deckhead to an extent necessary to ensure that every square foot of the vehicle deck surface is protected, including platform decks and the area of the deck below them. The pipes are fitted with open spray heads spaced so as to provide the required water density at the car deck level.

The installation is divided into sections along the length of the compartment, each section being not less than 20 m (60 ft) in length and extending over the breadth between the shell or casings. The system is kept charged at the necessary pressure between the pump and the control valves for each section. The control valves are situated in a control room on the vehicle deck and would be readily accessible with a fire in the vehicle space.

The pumps serving this system should be capable of being brought into operation by remote control, which may be manually actuated, from a position at which the distribution valves are situated. This position should be one which will be readily accessible when there is a fire in the protected compartment.

The water density normally required is 5 litres per sq. m (0·1 gallons per sq. ft) per minute and since vehicles may be stowed in such a way that they bridge two sections, the capacity of the system has to be capable of operating any two adjacent sections simultaneously at the required pressure.

Water amounting to 200 to 300 tons per hour can be discharged from a water spray system and if this is allowed to collect on the car deck it can cause grave loss of stability. Arrangements must, therefore, be provided to remove the water as quickly as possible. Where possible this is achieved by fitting 150 mm (6 in) diameter overboard scuppers about 10 m (30 ft) apart. Where the position of the car deck relative to the water line does not permit this, the water must be drained to the lower parts of the ship and pumped overboard.

When scuppers are provided they should not have a grating, which could be stopped easily, for example, by a sheet of scrap paper, instead a bar may be fitted.

5.3.3 Steam smothering systems

Steam smothering installations consist of simple piped systems arranged to deliver the steam to the fire hazard area. The pipes are connected to valve chests which must be readily accessible and each valve must be clearly marked to indicate which compartment it serves. The pipes from the distribution valve chests to the discharge end must be of steel galvanised inside and outside or of copper alloy and suitable for the maximum pressure of the steam. They must be arranged to discharge low down in the protected spaces, but kept clear of water and obstructions.

The steam is discharged through a series of holes generally about 12 mm (½ in) diameter drilled in the pipes.

In spaces more than 18 m (60 ft) long there should be at least two widely spaced distribution pipes.

As for all fire extinguishing systems, steam smothering installations should be available for immediate use, the system must not be dependent on the lighting of boiler fires. Although undesirable for fire fighting, blank flanges are sometimes fitted in the steam supply pipes to prevent inadvertent cargo damage; in such cases they must be of the spectacle type so that the presence of the blank flanges is obvious. These flanges must be readily accessible for removal and the securing nuts should be of brass.

5.3.4 Carbon dioxide systems

5.3.4.1 General

Carbon dioxide is, next to water, the most commonly used fire fighting medium. It is widely used in machinery spaces (Class B fires) and dry cargo holds (Class A fires). It is also used for the cargo tanks of oil tankers, although this practice is rapidly dying out. It is suitable for extinguishing fires in most substances, but should not be used for risks involving materials which incorporate their own oxygen for combustion, such as cellulose nitrate, nor the metals sodium, potassium and magnesium.

5.3.4.2 Quantity

Since the Rules do not envisage the simultaneous outbreak of fire in two risk areas, the one charge may serve for all compartments such as the machinery room, cargo pump room and cargo holds.

The capacity for machinery space protection is required to be at least equal to the larger of the following two quantities: —

(a) 40 per cent of the gross volume of the largest space, the volume to include the casing up to the level at which the horizontal area of the casing is 40 per cent or less of that of the space concerned.

(b) 35 per cent of the entire volume of the largest space including the casing. For cargo pump rooms the capacity is to be at least equal to 35 per cent of the gross volume of the space.

For cargo holds the capacity is required to be at least 30 per cent of the gross volume of the largest hold, although for cargo spaces intended for the carriage of motor vehicles with petrol in their tanks, it is recommended that the capacity of CO_2 be at least 45 per cent of the largest such space.

The volume of gas is calculated at 0,56 cu. m to the kilogramme (9 cu. ft to the pound).

5.3.4.3 Storage

There are two basic types of CO_2 systems, the difference being the method of storage. One is a high pressure system in which the charge is stored as a liquid at normal temperature in a number of cylinders generally with a capacity of 45 kg (100 lb). The other is a low pressure or bulk storage system in which the charge is stored in one or more large tanks and maintained at a pressure of about 300 p.s.i. by refrigeration. In both systems the CO_2 cylinders or tanks should be situated in a room which is readily accessible, dry, well lighted and well ventilated. The room should not be adjacent to a protected cargo compartment. It should preferably not be adjacent to a machinery compartment, however, when this cannot be arranged the common boundaries between the room and the machinery space should be constructed to A-60 standard. Access to the room should preferably be from the open deck; access from a protected machinery compartment is not permitted and any access from an accommodation area must be by a gas tight door.

In high pressure systems the CO_2 cylinders must be constructed and tested to British Standard B.S.401:1931, B.S.1287:1946, B.S.1288:1946 or Home Office Specification 'S', or to an equivalent standard recognised by a reliable

national authority. They should be stamped with the weights when empty and full, the name of the contents, the test pressure, the date of testing and the official stamp of the inspecting authority. They are secured in rows and connected to a manifold by loops of copper or reinforced rubber. There is a non-return valve at the connection of each loop to the manifold, so that the system will remain operable when one or more cylinders are removed or damaged.

The cylinder heads are provided with valves which are opened by levers either individually or in groups by an interconnecting wire, so that 85 per cent of the required gas can be discharged into a machinery space within two minutes (*see* Fig. 9).

In large ships it is necessary to open a large number of cylinders simultaneously and to do so by hand would be impossible. Arrangements are, therefore, made to release either one or two pilot cylinders by hand. These discharge into a small servo cylinder and depress a piston which in turn pulls a wire and opens the required number of cylinders.

In low pressure systems the CO_2 tanks are Class I pressure vessels constructed of steel of a quality which is suitable for the low temperatures involved, i.e. $-18°C$ ($0°F$) where the pressure is about 20 bar (300 p.s.i.).

The CO_2 is maintained at the required low temperature by a refrigerating unit. The storage vessel is heavily lagged with thermal-insulating material, consequently the rate of heat transfer is small and should a breakdown of the refrigerating unit occur there would be a considerable delay before the CO_2 pressure would rise to the point where the safety valve functioned. Should the safety valve open, CO_2 vapour would be released; this would be replaced by evaporation from the surface of the liquid so that the contents would refrigerate themselves and thus hold down the pressure. Even in summer temperatures it is likely to be about 24 hours before there is any serious loss of gas. However, a duplicate refrigerating unit is provided and arranged for automatic standby duties.

The storage vessels must be provided with relief devices and duplicate means of ascertaining the quantity of CO_2 which they contain. An automatic alarm is provided to indicate when 2 per cent of the contents have been lost.

The alarm systems and one of the refrigerating units should be arranged to operate from two sources of supply, one of which should be the emergency source of electrical power.

The system is replenished with liquid CO_2 delivered by road tanker and since such facilities are not yet available throughout the world, difficulty may be experienced in having a discharged system recharged.

The discharge pipe draws liquid CO_2 from the bottom of the tank and incorporates a 'U' bend to ensure that the normally pressurised part of the discharge pipe contains gaseous and not liquid CO_2 and thus avoids an excessive overload on the refrigeration plant. The outlet valve is a manually controlled stop valve, thus giving a finer control on the discharge than can generally be achieved with the high pressure system.

5.3.4.4 **Distribution**

Since the storage vessels contain only CO_2 vapour and its parent liquid, the pressure of the system is independent of the quantity of the substance present and is determined solely by the temperature. For CO_2 at normal temperatures the pressure is in the region of 48 to 55 bar (700 to 800 p.s.i.) therefore its own pressure is more than enough to propel it through a piped system.

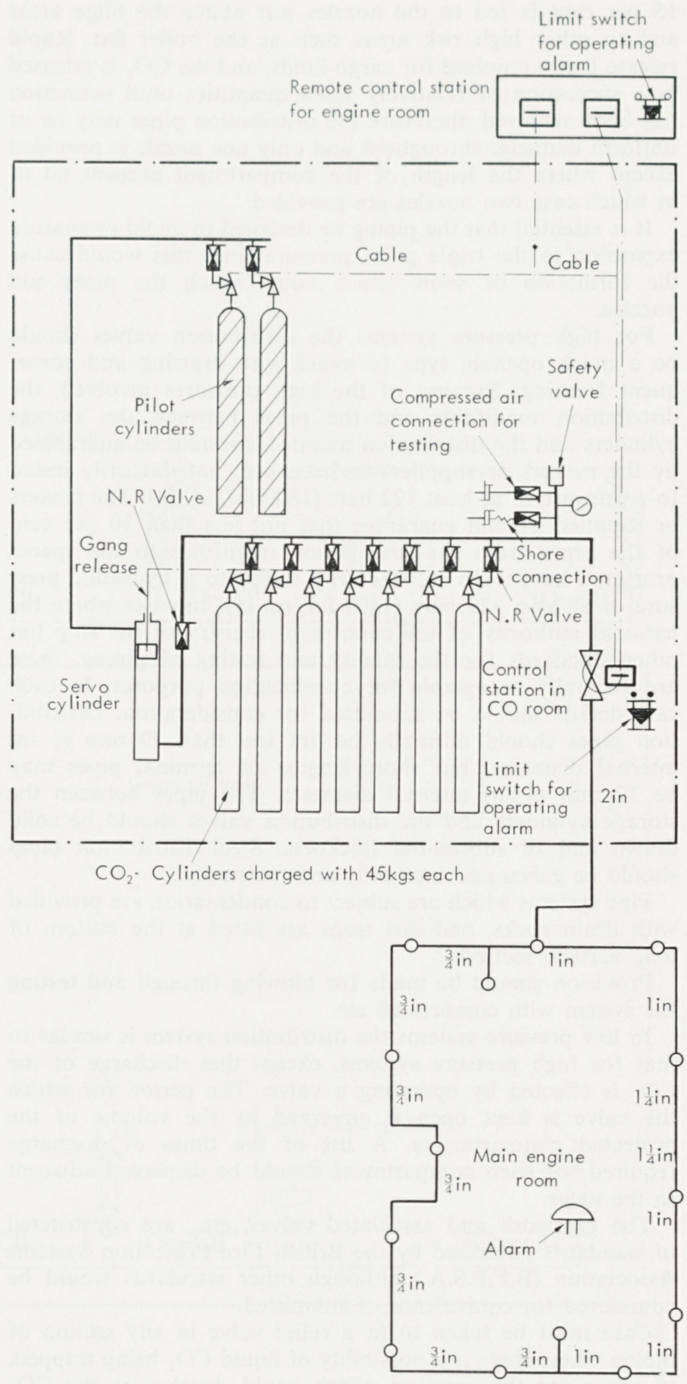


FIG. 9

Typical high pressure CO_2 system.

The charge is delivered from the storage vessels to the protected areas by a simple system of pipes. In the machinery spaces, since it is required that 85 per cent of the required volume of gas be discharged within two minutes, the diameter of the pipes is graded to provide an even distribution to all parts of the compartment. Generally most of the discharge is centred between the deckhead and the tank top, but about

15 per cent is fed to the nozzles just above the bilge areas and to other high risk areas such as the boiler flat. Rapid release is not required for cargo holds, and the CO_2 is released in a succession of relatively small quantities until extinction has been achieved, therefore the distribution pipes may be of uniform diameter throughout and only one nozzle is provided except where the length of the compartment exceeds 60 ft, in which case two nozzles are provided.

It is essential that the piping be designed to avoid premature expansion to the triple point pressure since this would cause the formation of snow which could block the pipes and nozzles.

For high pressure systems the distribution valves should be a quick opening type to avoid wire drawing and consequent freezing. Because of the high pressures involved, the distribution manifolds and the pipes between the storage cylinders and the distribution manifolds should be guaranteed by the makers or suppliers to have been satisfactorily tested to a pressure of at least 122 bars (1800 lbf/sq. in). The makers or suppliers should guarantee that not less than 10 per cent of the pipes from the distribution manifolds to the spaces protected have been satisfactorily tested to a hydraulic pressure of at least 122 bars (1800 lbf/sq. in). In cases where the national authority of the country of registry of the ship has other standards for the quality and testing of piping, these are generally acceptable for classification purposes. In each case details should be submitted for consideration. Distribution pipes should normally be not less than 19 mm ($\frac{3}{4}$ in) internal diameter, but short lengths of terminal pipes may be 12 mm ($\frac{1}{2}$ in) internal diameter. The pipes between the storage cylinders and the distribution valves should be solid drawn and of substantial thickness. Steel distribution pipes should be galvanised internally and externally.

Pipe systems which are subject to condensation are provided with drain cocks, and dirt traps are fitted at the bottom of long vertical sections.

Provision should be made for blowing through and testing the system with compressed air.

In low pressure systems the distribution system is similar to that for high pressure systems, except that discharge of the CO_2 is effected by operating a valve. The period for which the valve is kept open is governed by the volume of the protected compartments. A list of the times of discharge required for each compartment should be displayed adjacent to the valve.

The pipework and associated valves, etc., are constructed to standards published by the British Fire Protection Systems Association (B.F.P.S.A.) although other standards would be considered for equivalence, if submitted.

Care must be taken to fit a relief valve in any section of piping where there is a possibility of liquid CO_2 being trapped, to allow for the pressure which could develop as the CO_2 became heated. These relief valves should be fitted on a vertical standpipe not less than 300 mm (12 in) in length to ensure that they are not in contact with liquid CO_2.

In both high and low pressure systems the aim is to achieve liquid flow as far as the nozzles, although there is a period after release of the charge when the pipes will carry first air at an increasing pressure and then a mixture of CO_2 vapour and snow particles. The nozzles are specially designed to reduce the velocity of the discharge and to vaporize the CO_2. They consist of a divergent horn of a length suited to the nature of the protected area. Because of the forces involved they must be efficiently secured.

5.3.4.5 Controls

The system should be controlled from the storage room, although additionally, means may be provided for release from another position such as an exit from the engine room. The release mechanism should be simply operated and preferably arranged so that the directional valve must be opened before the charge is released. Simple and clear instructions for operating the system must be displayed near the control valves and in the CO_2 storage room. When the installation is used to protect the cargo pump room of a tanker, a notice should be displayed indicating that the system is not to be used for inerting purposes.

5.3.4.6 Alarms

An automatic alarm must be provided in all working spaces fitted with a CO_2 installation. It should emit a signal distinct from all other alarms and be audible when all machinery is operating at maximum power.

When the alarm is electrically operated it should be powered by batteries or through the emergency switchboard. If air operated, it may be supplied from the main air receivers through a safeguarded supply line. When an electrically operated alarm is fitted in a pump room it should be intrinsically safe. When air operated alarms are fitted they should be safeguarded against the possibility of static discharge.

5.3.5 Foam systems

5.3.5.1 General

Foam systems are intended for use on Class B fires, i.e. those involving flammable liquids or liquefiable solids, therefore low expansion or high expansion systems are used in main machinery spaces and cargo pump rooms where accumulations of oil fuel and cargo oil may occur and low expansion systems are used on the decks of oil tankers and chemical tankers for fighting fires involving deck spillages and the contents of cargo tanks which have been opened up by collision or explosion.

5.3.5.2 Fixed low expansion foam systems in machinery spaces and cargo pump rooms

These systems consist of one or more sections of piping fitted over separate fire risk areas. Foam solution consisting of foam concentrate and water in the correct proportions, is supplied from a control station and discharged through nozzles designed to introduce air and direct the resulting foam evenly over the hazard area.

In the control room the water and foam solution is formed in a venturi device supplied with foam concentrate from a supply tank and sea water supplied by a pump; alternatively a foam concentrate pump may be employed for direct injection (*see* Fig. 10).

The control room and the water pump must be situated in positions which would not readily be affected by a fire in the protected compartments.

The hazard areas are isolated by coamings which should be about 300 mm (12 in) high to contain the oil spillage and the foam layer. The system should be capable of supplying a 150 mm (6 in) depth of foam over the largest protected area in five minutes and over all the areas simultaneously within ten minutes. A number of hydrants with hoses and nozzles should also be fitted in the machinery space to direct foam onto residual fires and any spread of fire beyond the range of the fixed system.

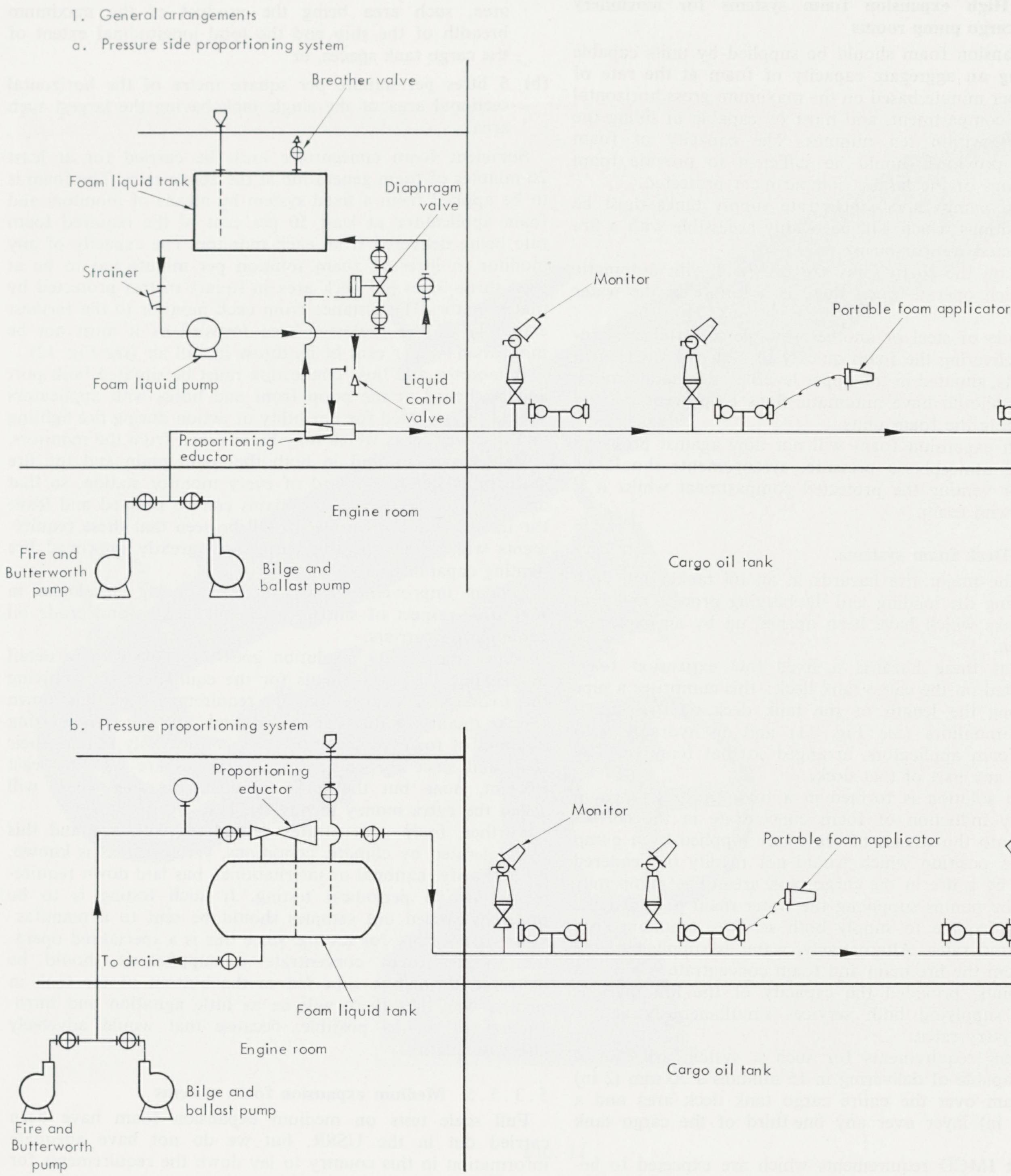


FIG. 10

Typical air-foam fire extinguishing system for decks.

The distribution pipes are generally of steel, galvanised internally and externally.

5.3.5.3 **High expansion foam systems for machinery spaces and cargo pump rooms**

High expansion foam should be supplied by units capable of producing an aggregate capacity of foam at the rate of 1 m depth per minute based on the maximum gross horizontal area of the compartment, and must be capable of filling the compartment within ten minutes. The capacity of foam concentrate provided should be sufficient to provide foam for five fillings of the largest compartment protected.

The units, pumps and concentrate supply tanks must be fitted in positions which will be readily accessible with a fire in the protected compartments.

The fans on the foam units are provided with automatic cut-outs which operate when there is a failure in the water supply.

Ducts made of steel or another suitable material are provided for delivering the foam quickly to high risk areas such as boiler flats, situated in the upper levels of the engine room. These ducts should have automatic flaps to prevent the fire from damaging the foam units.

Since high expansion foam will not flow against pressures much above atmospheric pressure, arrangements should be provided for venting the protected compartment whilst it is being filled with foam.

5.3.5.4 **Deck foam systems**

Two of the major fire hazards in an oil tanker are deck spillage during the loading and discharging process and fires in cargo tanks which have been opened up by an explosion or a collision.

To combat these hazards a fixed low expansion foam system is fitted on the cargo tank deck: this comprises a pipe running along the length of the tank deck and serving a number of monitors (*see* Fig. 11) and/or hydrants with hoses and foam applicators, arranged so that foam may be delivered to any part of that deck.

The foam solution is formed in a foam control room in the poop by induction of foam concentrate in the correct proportion into the stream of sea water supplied by a pump situated in a position which would not readily be rendered inaccessible by a fire in the cargo tank area. The pump may be one of the pumps supplying the water main provided the capacity is adequate to supply both services simultaneously at the required rates. Alternatively, water is supplied to the monitors from the fire main and foam concentrate is induced at these points, provided the capacity of the fire main is capable of supplying both services simultaneously at the required delivery rates.

The present requirements for such a system are that it should be capable of delivering in 15 minutes a 50 mm (2 in) layer of foam over the entire cargo tank deck area and a 150 mm (6 in) layer over any one-third of the cargo tank deck area.

The latest IMCO requirements which are expected to become mandatory in the near future (*see* Section 6) in respect of crude oil tankers 100 000 tons deadweight and over and crude oil combination carriers 50 000 tons deadweight and over are more stringent. They require that the rate of application of foam solution (i.e. foam concentrate and water in the correct proportions) should be not less than the following:—

(a) 0,6 litres per minute per square metre of the cargo deck area, such area being the product of the maximum breadth of the ship and the total longitudinal extent of the cargo tank spaces, or

(b) 6 litres per minute per square metre of the horizontal sectional area of the single tank having the largest such area.

Sufficient foam concentrate must be carried for at least 20 minutes of foam generation at the above rates. The foam is to be applied from a fixed system by means of monitors and foam applicators, at least 50 per cent of the required foam rate being delivered from each monitor. The capacity of any monitor in litres of foam solution per minute has to be at least three times the deck area in square metres protected by that monitor. The distance from each monitor to the farthest extremity of the protected area forward of it must not be more than 75 per cent of its throw in still air (*see* Fig. 12).

A monitor and hose connection must be situated both port and starboard at the poop front and hoses with applicators should be provided for flexibility of action during fire fighting and to cover areas which may be screened from the monitors.

Valves are required in both the foam main and the fire main immediately forward of every monitor station, so that any damaged section of the mains can be isolated and leave the intact section operable. It will be seen that these requirements will, when operable, provide a greatly improved fire fighting capability.

Similar improvements are currently being developed in IMCO in respect of smaller crude oil tankers and crude oil combination carriers.

Whilst the IMCO resolution goes into considerable detail in defining the requirements for the equipment for applying the foam, it is strange that no requirements are laid down for the quality of the foam to be used. The fire extinguishing qualities of foam concentrates vary considerably as does their cost, and since the cheapest concentrates are also the least efficient, none but the most fire-conscious shipowners will spend the extra money to buy the best.

Further, foam concentrates deteriorate with age and this is accelerated by climatic conditions, yet so far as is known, no authority, national or international, has laid down requirements for its periodical testing. If such testing is to be properly carried out samples should be sent to a manufacturer's laboratory for testing, since this is a specialised operation. When foam concentrate is supplied it should be delivered through a tube led to the bottom of the tank in such a way that there will be as little agitation and introduction of air as possible, because that would adversely affect its quality.

5.3.5.5 **Medium expansion foam systems**

Full scale tests on medium expansion foam have been carried out in the USSR, but we do not have adequate information in this country to lay down the requirements for such a system.

If such a system was submitted for approval it would be specially considered and tests would be required to establish its fire extinguishing capability and suitability for the purpose.

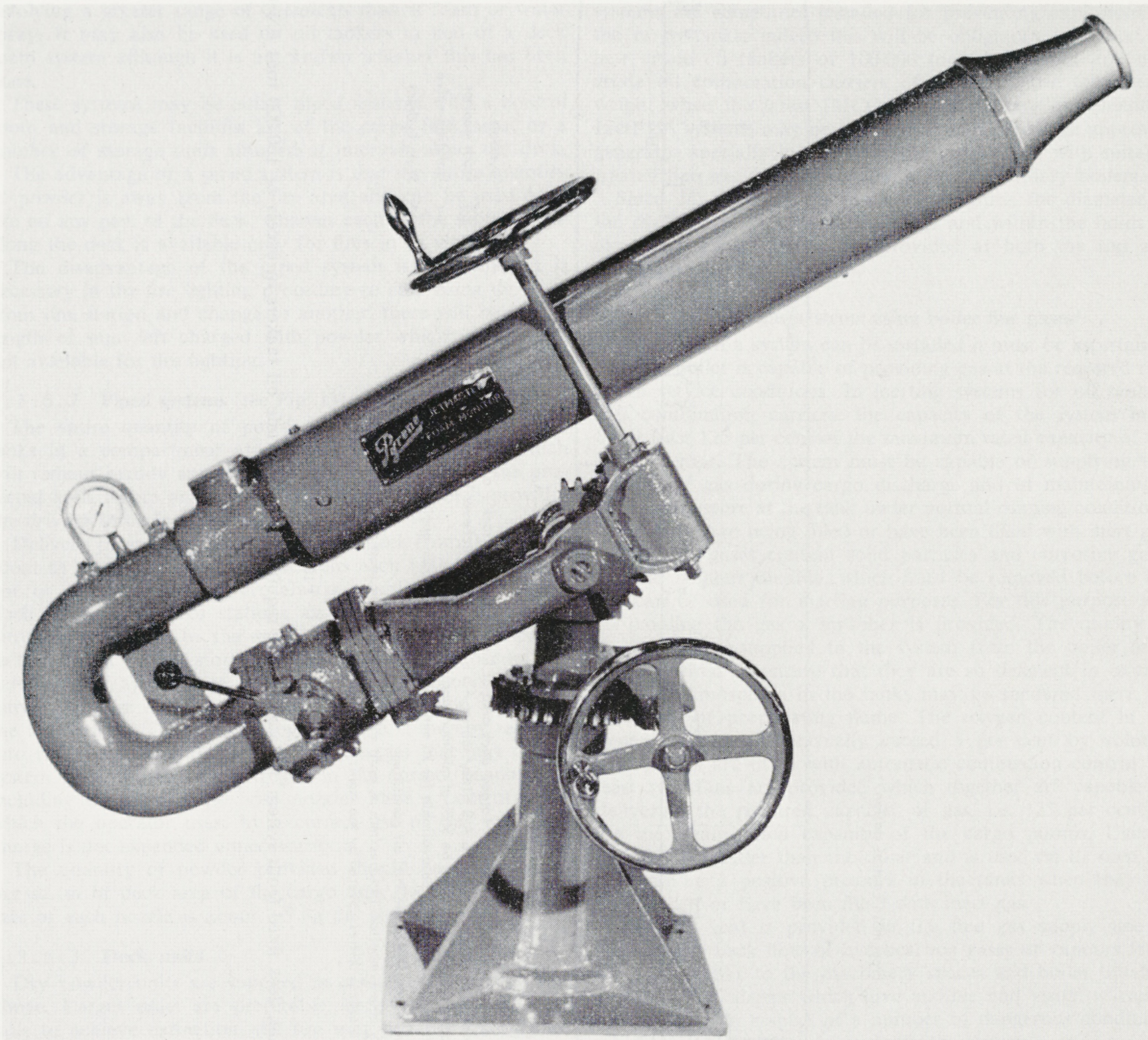
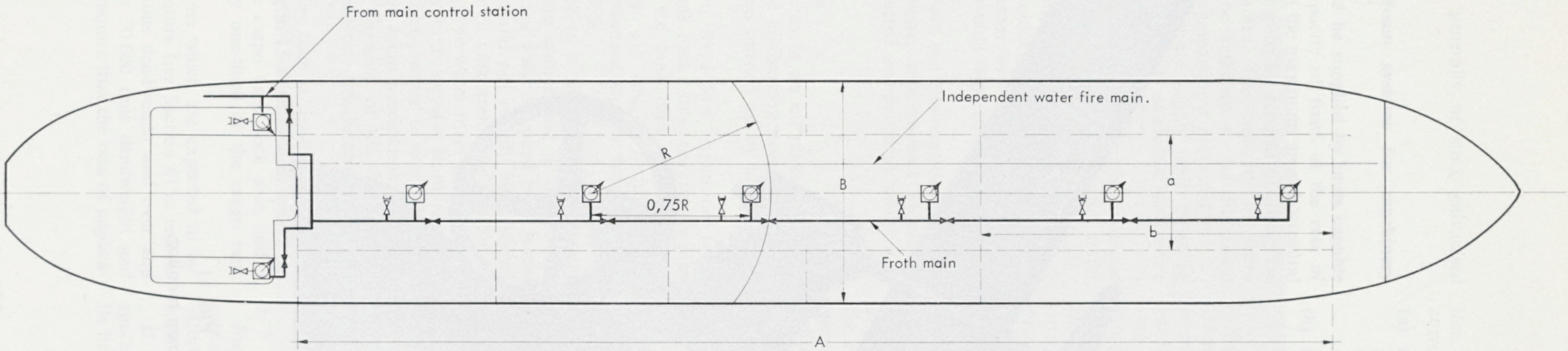


FIG. 11
Foam monitor.



Cargo tank deck area = A x B metres . Largest deck area of individual cargo tank = a x b
Minimum froth application rate = 0,6 A B litres/ min or 6 a b litres/ min whichever is greater
Minimum capacity each monitor to be 50% of minimum application rate
Sufficient froth concentrate to be available for 20 min operation at minimum application rate

R = the throw of the monitor in still air conditions

The capacity of any monitor in litres/min of froth solution should be at least three times the deck area in square metres covered by the monitor

Symbols.
Froth monitor
Isolating valve
Froth hydrant

FIG. 12

Cargo tank deck fixed froth system, to latest IMCO requirements for crude oil tankers in excess of 100 000 tons d.w.t.

5.3.6 Dry powder systems

5.3.6.1 General

Dry powder is an especially useful extinguishing agent for use against Class C fires (i.e. those involving gases), therefore, it is provided on ships for the carriage of liquefied gases. It is also used on many ships for the carriage of dangerous liquid chemicals in bulk, since it is effective against fires involving a greater range of chemicals than is foam or water spray. It may also be used on oil tankers in lieu of a deck foam system although it is not known whether this has been done.

These systems may be either piped systems with a control room and storage facilities aft of the cargo tank area, or a number of storage units situated at intervals along the deck.

The advantage of a piped system is that the entire quantity of powder is away from the fire area and can be used on a fire on any part of the deck, whereas each of the units spaced along the deck is available only for fires in its vicinity.

The disadvantage of the piped system is that when it is necessary in the fire fighting procedure to stop using the hose from one station and change to another, there will be a long length of pipe left charged with powder which is therefore not available for fire fighting.

5.3.6.2 Piped systems (*see* Fig. 13)

The entire quantity of powder is stored in one or more tanks in a compartment aft of the cargo tank deck, which will remain readily accessible when there is a fire in the protected area. There are bottles of nitrogen gas which provides the driving force for the system.

Delivery pipes are arranged along the deck from the storage room to a number of control stations each with a valve and one or two hoses, which are always coupled to the system. Each of these control stations also has a small charge of nitrogen connected to the main valve and the appropriate section valve in the storage room. When a fire occurs the valve at the appropriate control station is opened and the nitrogen charge opens both the appropriate section valve and the main valve. The main nitrogen charge is thereby released into the powder storage hopper and charges that part of the system with powder and nitrogen in the correct proportions including the hoses. The hose nozzles have a control valve which the operator uses; by a correct use of this valve the charge is not expended unnecessarily.

The quantity of powder provided should be about $1\frac{1}{2}$ kg per sq. m of deck area of the cargo tank deck. The delivery rate of each nozzle is about 3·5 kg per second.

5.3.6.3 Deck units

Dry powder units are supplied in capacities of 150 kg and above. Larger units are preferable, because if a small unit fails to achieve extinction, the fire may grow to its original intensity before a second unit may be brought into operation. Units should in general not be less than 250 kg.

The units should be firmly secured in positions where they will not be subjected to damage from the weather or by cargo operations.

Each unit has a hopper containing powder and a supply of nitrogen under pressure. When the nitrogen is released it enters the hopper at the base and creates turbulence and the resulting mixture of nitrogen and powder charges the one or more hoses which are attached. Each hose has a nozzle with an at-will valve to prevent wastage of the charge.

5.3.7 Inert gas systems

5.3.7.1 General

Inert gas systems are accepted as the fixed fire smothering systems required in the holds of dry cargo ships. They are not suitable for this purpose in machinery spaces, because the rate of gas production is inadequate.

In oil tankers and combination crude carriers, inert gas systems are sometimes installed for preventing explosions in the cargo tanks; indeed this will be obligatory in respect of new crude oil tankers of 100 000 tons deadweight and new crude oil combination carriers of 50 000 metric tons deadweight when the latest IMCO Regulations are implemented. Inert gas systems may be supplied with gas from an approved generator specially installed for the purpose, or with suitably treated flue gas drawn from the main or auxiliary boilers.

Since the gas is produced at low pressure, the diameter of the distribution pipes is rather large and within the holds of dry cargo ships, outlets are provided at both the top and bottom of the compartment.

5.3.7.2 Inert gas systems using boiler flue gases

Before such a system can be installed it must be ascertained that the boiler is capable of providing gas at the required rate in all service conditions. In inerting systems for oil tankers and combination carriers, the capacity of the system must be at least 125 per cent of the maximum rated capacity of the cargo pumps. The system must be capable of supplying this volume of gas during cargo discharge and of maintaining a positive pressure at the tank under normal running conditions, when tanks are being filled or have been filled with inert gas.

The flue gases contain solid particles and corrosive gases such as sulphur dioxide, which must be removed before the gas can be used for inerting purposes. For this purpose and for cooling the gas a scrubber is provided. The quality of the flue gases supplied to the system from the boiler must be monitored to ensure that they are so deficient in oxygen that the atmosphere in the tanks may be rendered inert, i.e. incapable of propagating flame. The oxygen content in the system should not normally exceed 5 per cent by volume. The boilers are fitted with automatic combustion control. At least two fans are provided which together are capable of delivering the required capacity of gas, i.e. 125 per cent of the maximum rated capacity of the cargo pumps. Usually one fan is smaller than the other and is used on its own for maintaining a positive pressure in the tanks when they are being filled or have been filled with inert gas.

A water seal is provided in the flue gas supply line to prevent any back flow of hydrocarbon gases or vapours from the cargo tanks to the machinery spaces and boiler uptakes. Cut-outs and alarms which give audible and visual warnings are provided in respect of a number of dangerous conditions which might arise due to faults in the system.

An instruction manual must be provided, covering operational, safety and occupational health requirements.

5.3.7.3 Inert gas systems with independent generators

The systems are similar to inert gas systems using flue gases from the boiler uptakes, except that the gas is produced by units in which diesel oil is burnt under controlled conditions.

The units are situated in compartments clear of the cargo tank deck.

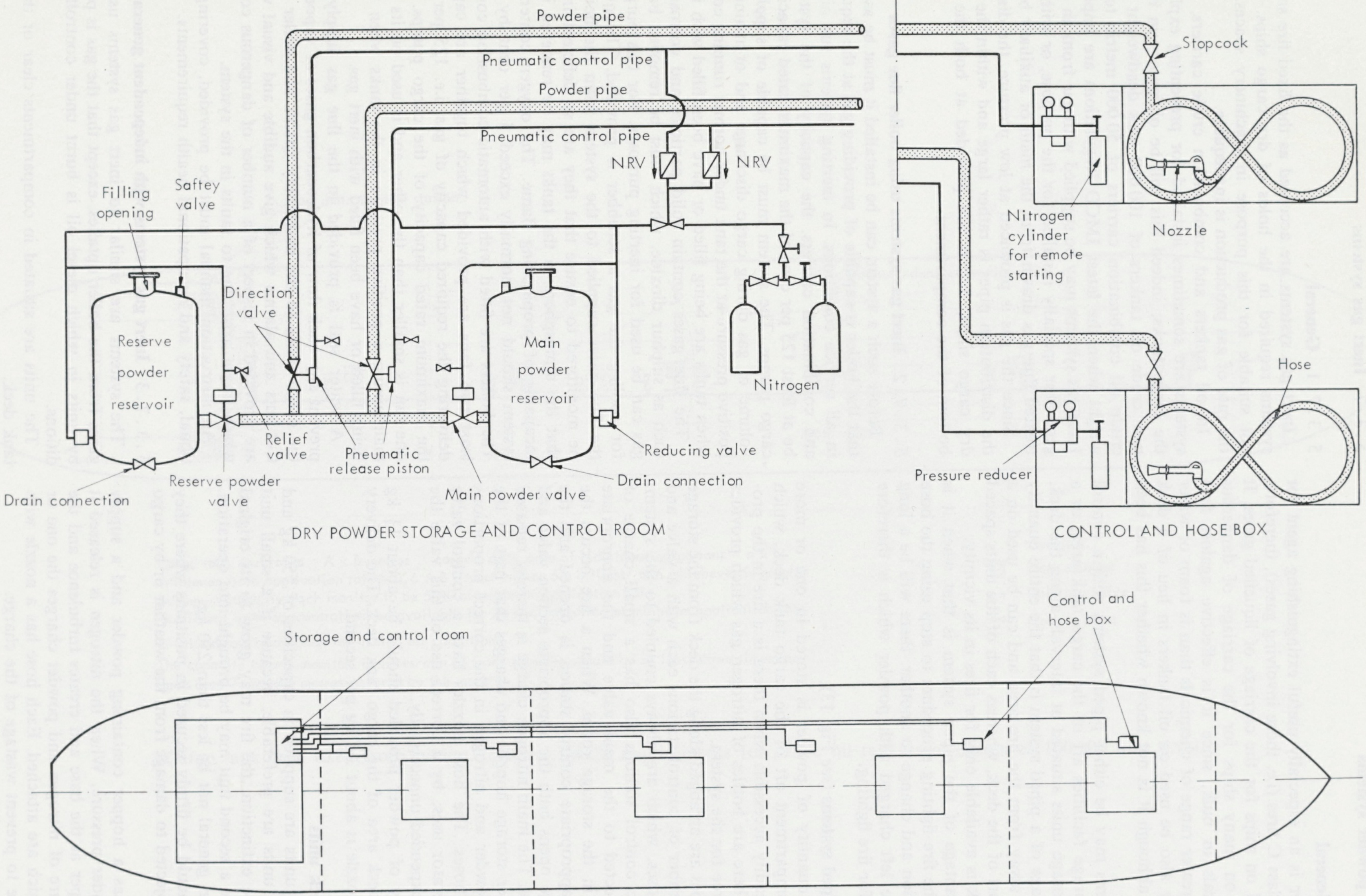


FIG. 13

Typical dry powder fixed system.

5.4 Portable fire extinguishers

5.4.1 General

There are five main types of portable fire extinguishers, viz. water, foam, CO_2, dry powder and vaporizing liquids. Of each of these there are numerous designs on which information can best be gleaned from the maker's catalogues.

The Convention defines a portable fluid extinguisher as one which contains not more than 3 gallons (13½ litres) and not less than 2 gallons (9 litres) and the capacities of other types should be within equivalent limits. However, smaller capacities are sometimes accepted for limited local risks such as a radio room. The choice of portable extinguishers to be used for a particular risk must be decided in relation to the nature of the fire which may be anticipated. The wrong choice of extinguisher could have disastrous results.

The following tables set out the type of fire risk for which each type of extinguisher is suitable.

TABLE I

PORTABLE EXTINGUISHERS

Type	Class of fire for which suited	Suitability for fires involving electrical equipment	Size suitable for ship use
Water	A	No	9 litres (2 gallons)
Foam	ABC	No	9 litres (2 gallons
Co_2	BC	Yes	(10lbs)
Dry powder	ABC	Yes	2,7 kg (6lbs)
BCF	ABC	Yes	1,5kg (3 lbs)
BTM	ABC	Yes	1,5kg (3lbs)

Note 1 TYPE D FIRES require a specially suited dry powder. All the above types would cause an explosion when used on fires involving some metals.

TABLE II

GUIDE TO LOCATION OF PORTABLE EXTINGUISHERS

Risk	Suitable type of extinguishers	Stowage position
Accommodation spaces	Water	In corridors near the entrances
Public rooms	Water	Just inside the doors
Galley	Foam, dry powder or CO_2	Near the exits
Radio room	CO_2, B.C.F. or B.T.M.	Just outside the door
Engine room	Dry powder or foam	On each level where there is a fire risk
Boiler room	Foam	Near the exits
Electric switchboard	CO_2	Near to switchboard

The positioning of portable extinguishers is also important. They are intended to be 'first aid' equipment, therefore they should be readily available. One should be stowed near each entrance to an accommodation area or major compartment, so that it may easily be found by a person entering the area when it is on fire instead of having to waste valuable time searching for the appliance when visibility is reduced by smoke. A portable extinguisher should also be stowed near to each major fire risk. Every portable extinguisher should have displayed on it clear instructions for its operation.

Attempts have been made to introduce a colour code for differentiating types of extinguishers, e.g. red for water, black for CO_2, green for foam, yellow for dry powder and blue for vaporizing liquids, but this has not yet been adopted universally.

5.4.2 Water (soda acid) extinguishers

This is a very common type of extinguisher in which the canister is filled with an aqueous solution of sodium bicarbonate. There is a small sealed bottle containing sulphuric acid at the top of the extinguisher and when this is broken the two components react to form sodium sulphate, water and carbon dioxide. The carbon dioxide provides the pressure to discharge the contents through a nozzle in a jet.

5.4.3 Water (gas cartridge) extinguishers

The canister contains two gallons of water and a cartridge of about 2 oz of CO_2 secured at one end where there is a plunger. When the plunger is depressed it pierces the seal of the cartridge and releases the CO_2 into the canister. The resulting pressure forces the water out of the nozzle in a jet.

5.4.4 Chemical foam extinguishers

The canister contains two separate charges, one aluminium sulphate, acting as a weak acid, and the other sodium bicarbonate to which a foam stabiliser has been added to give the foam bubbles a tough skin. When the operating mechanism brings the two components together, the reaction produces CO_2 which provides the pressure for ejecting the contents through the nozzle and also fills the bubbles. The expansion ratio of the foam is in the order of 8–12 to 1.

5.4.5 Air foam extinguishers (also referred to as mechanical foam extinguishers)

The canister may contain either a premixed solution of foam concentrate and water, or a plastic bag containing foam concentrate with water surrounding it. In both cases there is a small cartridge containing liquid CO_2.

When the extinguisher is operated the CO_2 cartridge is pierced and in the latter type breaks the plastic bag to enable the concentrate to dissolve in the water. In both types the CO_2 expels the solution through a short hose and a nozzle where a turbulence is created and air is admitted to form a jet of foam composed of air-filled bubbles. The rate of expansion is about 8 to 1.

5.4.6 Carbon dioxide extinguishers

These consist of steel cylinders containing liquid CO_2 fitted with a releasing mechanism connected to a short flexible hose with a horn and trigger operated valve.

When the release mechanism is operated, the vapour pressure in the cylinder drives the liquid into the hose. The operator can then release the charge in long or short bursts at will by squeezing the trigger. The liquid expands and vaporizes in the horn.

The cylinders generally contain about 10 lb of CO_2 which produce about 90 cubic feet of gas, which, being heavier than air, has a smothering effect on a fire.

5.4.7 **Dry powder extinguishers**

These consist of a canister containing about 6 kg (12 lb) of sodium bicarbonate and a small charge of liquid CO_2. The operating mechanism pierces the seal and the pressure of the CO_2 drives the powder through a tube, led from the bottom of the canister, into a flexible hose with a trigger operated nozzle. These extinguishers have a total discharge time of only about 12 seconds, it is therefore important that the operator releases the powder in short bursts.

Metallic stearates are added to the sodium bicarbonate powder to prevent caking due to moisture absorption.

5.4.8 **Vaporizing liquid extinguishers**

The construction of these extinguishers is generally similar to that of the CO_2 type, the medium being stored in liquid form and expelled under its own vapour pressure.

Those in common use contain carbon tetrachloride (C.T.C.) bromochlorodifluoromethane (B.C.F.) or bromotrifluoromethane (B.T.M.).

5.5 Firemen's outfits

5.5.1 General

In order to use the fire fighting equipment on board ship effectively, the men who are required to operate it must be protected against the effects of heat and smoke. They also require some small pieces of ancillary equipment including an axe and a lamp for obvious reasons and a lifeline to enable them to communicate with their colleagues and to be readily located should they become incapacitated in an obscured situation. A breathing apparatus is also provided. The breathing apparatus may consist of either a self-contained apparatus of approved type or a smoke helmet or mask supplied with air from a suitable air pump through a length of flexible hose of sufficient length to reach any part of the holds or machinery spaces from the open deck; if, in order to do this, the length of the hose would exceed 36 m (120 ft), a self-contained breathing apparatus must be substituted or provided in addition. The self-contained breathing apparatus is by far the better, since it provides the wearer with greater freedom of movement, also the long length of air hose in the other type is very vulnerable to damage from fire or falling objects.

The safety lamp should be electric and capable of operating continuously for at least three hours. It should be flameproof or intrinsically safe.

The axe should have a spike and a cutting edge and a short handle of wood or other well insulated material.

A belt should be provided, with provisions for attaching the lamp, the axe and the lifeline.

The Rules do not ask for protective clothing, but this is essential for fighting fires on the cargo tank decks of oil tankers, liquid gas carriers and liquid chemical carriers. They should consist of trousers, a jacket, gloves and boots of electrically non-conducting material and a helmet.

The number of firemen's outfits required varies according to the tonnage of the ship.

5.5.2 Self-contained breathing apparatus (*see* Fig. 14)

The design of this equipment varies, of course, according to the manufacturer's specification, but the basic principles are similar for all.

The apparatus consists of a face mask attached by a flexible hose to one or two cylinders containing air and supported on a frame and harness. The capacity of the air cylinders varies, but it is in the order of 1200 litres (40 cu ft) at a pressure of 132 bars (1980 p.s.i.) in the case of a one-cylinder set and 1600 litres (53 cu ft) at a pressure of 200 bars (3000 p.s.i.) in the case of a two-cylinder set.

In one commonly used apparatus the arrangement is as follows: —

The cylinders are connected to a reducing valve which reduces the pressure of the air passing through to about 60 lb/sq. in. The air then passes through a 'demand valve' which further reduces the pressure and passes air to the wearer as he inhales and closes when he exhales. An automatic valve releases exhaled air from the face mask. A by-pass valve is provided for use in emergencies and permits air to be supplied to the mask without passing through the reducing valve. The by-pass valve is adjusted by hand to give the required rate of supply; it must, of course, be used judiciously, because an injudicious increase in the rate of flow will greatly reduce the operating time of the set.

The operating time for a one-cylinder set is generally about 30 minutes, although this depends on the breathing rate of the wearer which in turn depends on the tasks which he must undertake. A two cylinder set will generally operate for about 40 minutes. When the air supply has been reduced to about ten minutes duration a whistle sounds continuously, warning the wearer to leave the hazard area immediately, or signalling his position to rescuers if he is unable to return and requires help.

The face mask is made of moulded rubber with a series of adjustable rubber straps to secure it to the head of the wearer and fitted with quick release arrangements. The visor should have a good field of vision so that the wearer does not need to turn his head constantly. A gauge is provided to indicate the pressure of the air in the cylinder.

To enable breathing apparatus to be used at low levels of compartments of deep ships where the 30 minute duration would not be adequate, arrangements are available for providing an initial supply of air through a long reinforced, flexible tube from cylinders on deck. At any time the wearer is able to switch to the supply from the cylinder he is carrying.

Equipment using compressed oxygen is not acceptable for use on board ships.

6 REGULATIONS

The requirements currently applicable to passenger ships and cargo ships are set out in the Society's Rules and in the International Convention for the Safety of Life at Sea, 1960.

Part G—Special Fire Safety Measures for Passenger Ships, and

Part H—Fire Protection, Fire Detection and Fire Extinction in Passenger Ships are set out in the Supplement to the International Convention for the Safety of Life at Sea, 1960. Although Part G and Part H were adopted by the Assembly of IMCO in 1966 and 1967 respectively, they have not yet become mandatory because they have not yet been adopted by the required number of countries which are members of IMCO. Steps are now being taken to include these requirements in a separate chapter on Fire Protection, Fire Detection and Fire Extinction in the 1974 Convention.

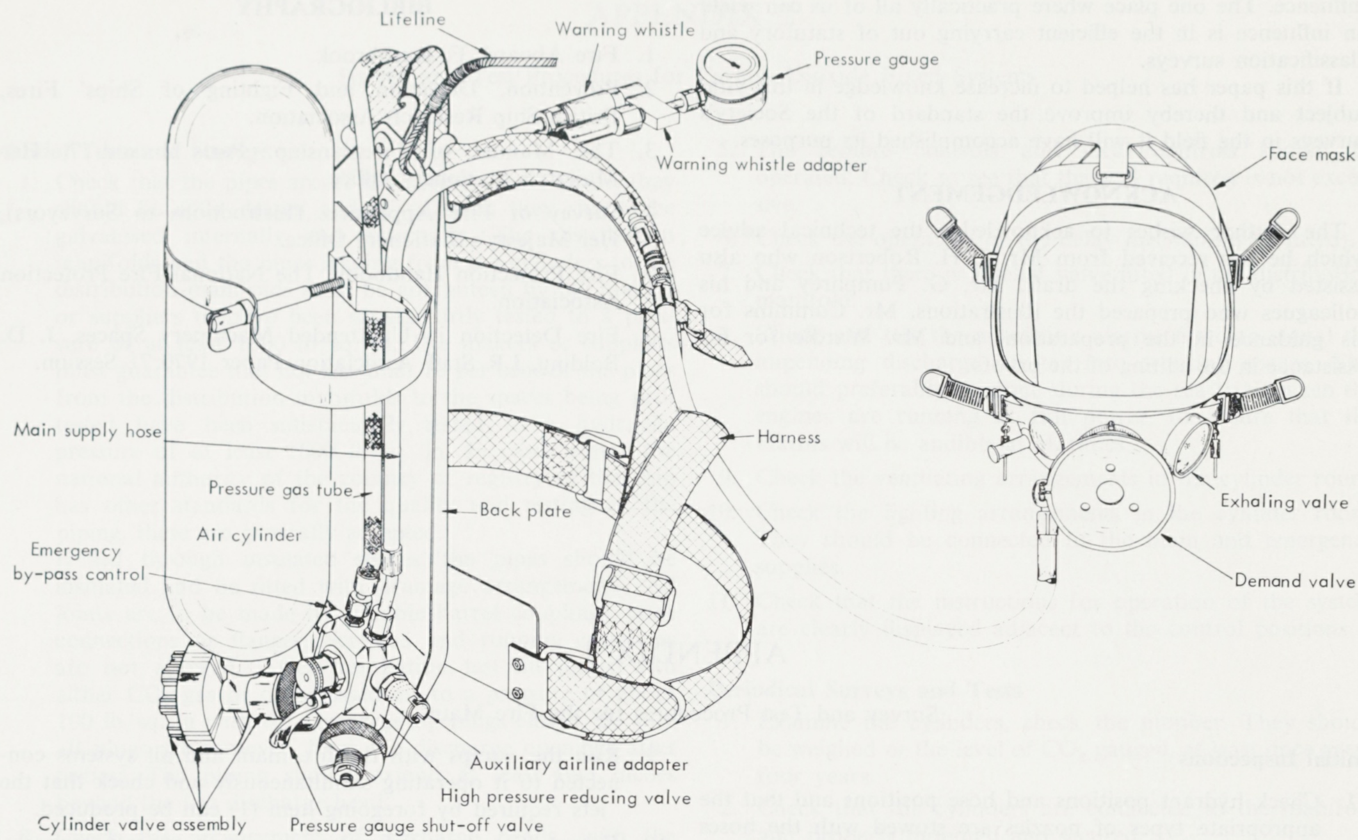


FIG. 14

Self-contained breathing apparatus.

Fire Safety Requirements for the Construction and Equipment of New Tankers and Combination Carriers were adopted by the Assembly of IMCO in November 1973 and will come into force, at least in some countries, on the 1st July, 1974. They will also be included in the separate chapter on Fire Protection, Fire Detection and Fire Extinction in the 1974 Convention.

Part J—Fire Protection of Cargo Ships is now under discussion in IMCO. It will not be ready for inclusion in the 1974 Safety Convention, but it is hoped that it will be ready for presentation to the next Assembly in 1975. It is intended at the 1974 Safety Convention to make provisions to facilitate its amendment at any time, more readily than under the present Convention, so no doubt Part J will be included as soon as it is adopted by the Assembly.

The requirements for ships intended for the carriage of dangerous liquid chemicals in bulk are set out in Chapter R(J) of the Society's Rules and in the IMCO Code for Chemical Carriers. In these regulations, the fire extinguishing equipment is required to be capable of extinguishing fires involving every cargo which the ship is intended to carry. They do not state the quantity of the fire extinguishing medium required, nor stipulate the rates of application. Each case is considered individually against the list of proposed cargoes.

The requirements for liquefied gas carriers are included in a code which is presently being developed by IMCO.

The IMCO Code for Fishing Vessels contains a chapter on Fire Protection, Fire Detection, Fire Extinguishing and Fire Fighting. These requirements are very comprehensive and are not obligatory.

Discussions are in progress in IACS for the simultaneous adoption and interpretation of parts of the above-mentioned IMCO documents and it is hoped that the Society's Rules will reflect this in due course.

7 FIRE AND EXPLOSION CASUALTY RECORDS

Regulations in respect of fire protection and extinction are influenced considerably by statistics of fires and explosions which occur in ships. The Society's Technical Records Department maintains a system in which are recorded particulars of all fires and explosions in ships, both classed and not classed with the Society, as and when they are made available. Surveyors should, therefore, promptly report particulars of any marine fires and explosions occurring in their area.

8 CONCLUSIONS

Fire casualty statistics are too high, both in terms of ships, cargoes and human life. Their reduction depends on improvements in the regulations, the maintenance of equipment and the training of fire crews. The Society is engaged in the development of improved regulations, through its association with IACS and IMCO, but few of us can participate in these activities. The training of fire crews is entirely outside our

influence. The one place where practically all of us can wield an influence is in the efficient carrying out of statutory and classification surveys.

If this paper has helped to increase knowledge in this vital subject and thereby improve the standard of the Society's surveys in the field it will have accomplished its purposes.

ACKNOWLEDGEMENT

The Author wishes to acknowledge the technical advice which he has received from Mr. J. H. Robertson who also assisted by checking the draft, Mr. G. Pumphrey and his colleagues who prepared the illustrations, Mr. Cummins for his guidance in the preparation, and Mr. Wardle for his assistance in the editing of the proofs.

BIBLIOGRAPHY

1. Fire Aboard, F. Rushbrook.
2. Prevention, Detection and Fighting of Ships' Fires, British Ship Research Association.
3. The Manual of Firemanship, Parts 1 and 7, Her Majesty's Stationery Office.
4. Survey of Fire Appliances (Instructions to Surveyors), Her Majesty's Stationery Office.
5. Fire Protection Handbook, The National Fire Protection Association.
6. Fire Detection in Unattended Machinery Spaces, J. D. Bolding, LR Staff Association Paper 1970–71 Session.

APPENDIX 1

Survey and Test Procedures for the Fire Main

Initial Inspections

1. Check hydrant positions and hose positions and that the appropriate types of nozzles are stowed with the hoses together with any tools necessary for their operation. These should be in accordance with the approved plan, but as such plans are often diagrammatic, the Surveyor should verify that two jets of water may be directed on any part of the ship including the cargo holds when empty. One such jet should be produced by a single length of hose. Check that combined jet and spray nozzles are readily adjustable.
2. Check that no systems are connected to the fire main other than those specifically catered for and permitted by the approved plans.
3. Check drain valves and isolating valves as shown on the approved plans.
4. Check that all manifold valves are readily accessible and clearly marked. They should be sited reasonably near to the pumps.
5. Check the length and diameter of the hoses.
6. Check the marking of the hose boxes.
7. Run the two fire pumps simultaneously, discharging through the fire main.
8. Test that an adequate jet can be produced simultaneously from the two highest hydrants using each pump singly, or from the two hydrants most remote from the pump if in the Surveyor's opinion that would be more onerous.
9. Run the pumps with the fire main and all systems connected to it operating simultaneously and check that the jets required by foregoing item (1) can be produced.
10. Ensure that the relief valves are set to operate properly, and discharge to a suitable location.
11. Check the starting of the emergency fire pump and test it discharging to all parts of the fire main outside the compartment containing the main fire pumps.
12. Check the international shore connections.

Periodic Inspections

1. Run each fire pump and check that the pumping capacity is adequate. Check the starting of the emergency fire pump.
2. Examine all hoses. They should be ranged, including those which look new. Pay particular attention to the attachment of the hoses to the couplings. Run water through each hose at pressure and check for leaks.
3. Ensure that water is flowing at each hydrant and that the hydrant valves are working and that the couplings are undamaged.
4. Examine the fire main, paying particular attention to the joints. Operate the isolating valves.
5. Check the nozzles and the international shore connections and any tools required for connecting the hoses.
6. Check the marking of the hose boxes.

APPENDIX 2

Survey and Test Procedures for Carbon Dioxide Fixed Systems

Initial Tests and Surveys

1. Check that the pipes are of the correct material, i.e. they should be solid drawn and, if of steel, they should be galvanised internally and externally. The distribution manifolds and the pipes leading from the cylinders to the distribution manifolds must be guaranteed by the makers or suppliers to have been satisfactorily tested to a pressure of at least 1800 lb/sq. in. The makers or suppliers must guarantee that not less than 10 per cent of the pipes from the distribution manifolds to the spaces being protested have been satisfactorily tested to a hydraulic pressure of at least 1800 lb/sq. in. In cases where the national authority of the country of registry of the ship has other standards for the quality and testing of the piping, these are generally accepted.
   If led through insulated spaces, the pipes should be insulated and be fitted with drainage arrangements. All joints are to be made by suitable barrel couplings, cone connections or flanges. Screwed and running couplings are not allowed. After installation test all joints with either CO_2 gas or compressed air to a pressure of about 100 lb/sq. in with the discharge openings closed. Be sure all plugs are removed from the discharge openings after testing. The piping should extend at least two inches beyond the last discharge head.
2. Check the arrangement of discharge heads, with the approved plans.
3. Check that dirt traps and drain traps are fitted.
4. Check the number of the CO_2 cylinders and that they are fully charged, fitted with a safety disc and marked with their weight when empty and the weight of gas they are fit to hold. The weight of CO_2 liquid must not exceed two-thirds of a pound for each pound of water capacity of the cylinder.
   The cylinders should be a type approved by a competent National authority. The safety discs should be a type which will burst at between 2600 and 2850 lb/sq. in pressure.
   Non-return valves should be fitted in the pipes leading from the cylinders to enable the cylinders to be disconnected without affecting the effective use of the other cylinders in the system.
   Check that the cylinders are properly mounted and secured and the gang release mechanism if any, is connected correctly. If a remote control is fitted the system should also be capable of operation entirely from within the cylinder room.
5. The remote controls and local controls should be operated. Check to see that the pull required is not excessive.
6. Check the operation of the delay mechanism (if fitted).
7. Check that there is a relief valve fitted in the distribution manifold.
8. Check and test the automatic alarms fitted to signal the impending discharge of gas into working spaces. This should preferably be done during the sea trials when the engines are running at full power, to ensure that the alarms will be audible at all times.
9. Check the ventilating arrangements in the cylinder room.
10. Check the lighting arrangements in the cylinder room. They should be connected to the main and emergency supplies.
11. Check that the instructions for operation of the system are clearly displayed adjacent to the control positions.

Periodical Surveys and Tests

1. Examine the cylinders, check the number. They should be weighed or the level of CO_2 gauged, at least once every four years.
2. Check that the cylinders are connected to the manifold and properly mounted and secured.
3. Examine the operating gear.
4. Blow through the system with compressed air and ensure that the air is discharged satisfactorily from each discharge head (particular attention should be paid to those heads discharging over the engine room bilges).
5. Test the audible alarms (if gas operated, compressed air should be used for the test; such air should be clean and dry if discharged into the cargo pump room of a tanker).
6. Check that dirt and drain traps are free.
7. Check the operation of the delay mechanism (if fitted).
8. Check that the operating instructions are displayed adjacent to the control position.
9. Where possible these tests should be carried out by a reliable specialist and witnessed by the Surveyor.

N.B.—When carrying out surveys and tests of CO_2 systems on ships registered in the Netherlands, authorisation must be first received from the Netherlands Shipping Inspectorate and the surveys should be carried out in accordance with their Notice to Shipping No. 97/1973 (*see* LR Circular No. 2275).

APPENDIX 3

Survey and Test Procedures for Fixed Foam Systems

Low Expansion Machinery Space Systems

1. Check that pump and control room are outside the protected space and readily accessible.
2. Check that the foam concentrate tank is full. There is no requirement for renewing old concentrate, but it is recommended that samples of protein foam liquid be sent to the supplier for testing at least every two years.
   If new foam concentrate is supplied it should be verified that it is the correct type (particularly in bulk chemical tankers).
3. Check that the pipes and nozzles are clear. In new systems this should be done by discharging foam. In existing systems, compressed air may be used.
4. Check the hydrants, hoses and foam applicators.
5. Check the height and water tightness of the coamings round the hazard areas.
6. Test the water/foam concentrate proportionating system in the control room.
7. Check that there is an operations instruction manual displayed in the control room.
8. The piping should always be flushed with water after foam has been used.

High Expansion Foam Systems

1. Check the pump and any change-over valves. These should be located in a readily accessible space outside the protected area.
2. Check the power supply to the fan. It should be supplied from the main and emergency sources.
3. Check that the screen is clean and intact.
4. Check any trunking and the operation of any valves in it.
5. Check the level of foam concentrate.
6. Run the system using the foam sampling branch provided.
7. Check that the fan cuts out when the water supply is cut off.
8. Check that there is an operating manual available.

Deck Foam System

1. Check the water pump and any change-over valves.
2. Check the piping system including any branches to permissible low demand systems.
3. Check the isolating valve on branch from the fire main (if any).
4. Check the positions of the hydrants, hoses, applicators and monitors.
5. Check the capacity of the foam concentrate. If the concentrate is protein type recommend that it be tested by the manufacturer.
   If any replenishment is carried out, check that the correct type is supplied.
6. Check the water/foam proportionating system.
7. Run the system to check the range of the monitors and the quality of the foam. Flush through with water after this test.
8. Check that there is an operations manual readily available in the control room.

APPENDIX 4

Survey and Test Procedures for Portable Fire Extinguishers

1. All portable extinguishers should be examined at each safety equipment renewal survey. If there is any sign of corrosion, leakage or damage, the extinguisher concerned should be tested by discharging, cleaned, repaired as necessary, hydraulically tested and refilled.
   The instructions for use should be clearly marked on the wall of the canister.
2. Soda acid type extinguishers dependent on unsealed acid charges should be tested by discharging at least once every two years and the charge renewed.
   All other water type extinguishers, foam, dry powder and carbon tetrachloride extinguishers should be tested by discharging once every four years.
   When the extinguisher has been discharged it should be examined for damage and corrosion and if such is found it should be cleaned and repaired as necessary and then tested to a hydraulic pressure at 300 lb/sq. in before recharging.
3. CO_2 extinguishers should be weighed at every safety equipment renewal survey and if the loss of weight exceeds 10 per cent of the weight of the contents when full as recorded on the outside of the cylinders, the extinguishers should be tested by discharging and refilled.
   If a cylinder is corroded or damaged, but in the opinion of the surveyor, based on a visual examination, not seriously enough to warrant its rejection, it should be subjected to a hydraulic pressure test before recharging it.
   All cylinders should be subjected to a hydraulic pressure test at least once every ten years, then after twenty years subsequent tests once every five years. If there is corrosion or damage to the cylinders all tests should be once every five years. In all cases the hydraulic test pressure should be 3,360 lb/sq. in.

C.T.C.—Test by discharge once every five years and 20 per cent each year provided that if any one fail then all must be tested.

D.P. —Gas Cartridge type. Test by discharge once every five years and 20 per cent each year provided that if any one fail the test then all must be tested.
Stored Pressure Type. Weigh annually. If loss of weight is noted extinguisher is to be discharged.

Except where stated otherwise, all extinguishers to be tested hydraulically to at least 300 lb/sq. in once every five years.

APPENDIX 5

Survey and Test Procedures for Breathing Apparatus

1 **Air Hose Type**

1 . 1 Examine the face mask for its general condition paying particular attention to the securing straps and the connection of the air hose.

1 . 2 Examine condition of the air hose.

1 . 3 Test the assembled set worn by a man, that the air delivery to the face mask is adequate.

2 **Self-contained breathing apparatus**

2 . 1 Examine the face mask for its general condition and particularly the straps for securing it to the head of the wearer and the condition of the visor.

2 . 2 Examine the condition of the tube from the reducing valve to the face mask.

2 . 3 Examine the condition of the air cylinders.

2 . 4 Connect each cylinder to the set and open the cylinder valve to check the pressure readings on the gauge. This should indicate that the cylinders are full by reference to the manufacturer's operations manual.

2 . 5 Get a man to wear the set and, with the face mask hanging free, gently open the by-pass valve and ensure that air is discharged into the face mask; this should be clearly audible. Shut the by-pass valve.

2 . 6 With the man wearing the face mask, restrict the air supply by bending the supply pipe, and the mask should collapse on the face after one or two breaths. Release the supply pipe immediately.

2 . 7 With the face mask removed, close the cylinder valve and open the by-pass valve and the warning whistle should sound as the air pressure falls.

2 . 8 All the above tests should be carried out under the direction of the responsible ship's officer who should see that the set is properly cleaned, disinfected, dried and stowed on completion.

2 . 9 The method of effecting the above mentioned tests will vary according to the design of the apparatus. Reference should be made to the manufacturer's instruction manual.

APPENDIX 6

List of plans required to be submitted for approval for all ships intended for the Society's Classification

1 **Fire Protection**

1 . 1 **Passenger Ships**

A general arrangement plan showing the main fire zones, escape stairways and the fire compartmentation bulkheads and decks within the main fire zones including the engine and boiler rooms, the galley, paint store, lamp room, navigating bridge, radio room, fire fighting control rooms, emergency generator rooms, battery locker.

A plan showing the details of construction of the fire protection bulkheads and decks and the particulars of any surface laminates employed.

A plan showing the construction of the fire doors.

A ventilation plan showing the ducts and any dampers in them, the position of the controls for stopping the system.

A plan showing the sprinkler system and/or detection system.

A plan showing the remote control for the fire doors.

A plan showing the location and arrangement of the emergency stop for the oil fuel unit pumps and for closing the valves on the pipes from oil fuel tanks.

A plan of the fire alarm systems.

1 . 2 **Cargo Ships**

A plan showing the layout of the accommodation and service areas and the fire retardant corridor bulkheads.

A plan showing the details of construction of the corridor bulkheads and ceilings.

2 **Fire Extinguishers**

A general arrangement plan showing the disposition of all the fire fighting equipment including the fire main, the fixed fire extinguishing systems in the cargo holds, on deck and in the machinery spaces, the disposition of the portable and non-portable extinguishers and the types used, the position and constitution of the firemen's outfits.

A plan showing the layout and construction of the fire main including the main and emergency fire pumps, isolating valves, pipe sizes and materials, the international shore connections and the cross connections to any other systems.

A plan showing details of each fixed fire fighting system including calculations for the quantities of the media used and the proposed rates of application.

3 **Fire Control Plans**

Each ship is required by the SOLAS Convention, Chapter II, Regulation 70, to have permanently exhibited for the guidance of the ship' officers, a fire control plan. A copy of this plan should be submitted for approval.

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Lloyd's Register Technical Association

Discussion

on

Mr. G. Coggan's Paper

FIRE PROTECTION, DETECTION AND EXTINCTION IN SHIPS

Paper No. 1. Session 1974-75

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The author of this paper retains the right of subsequent publication, subject to the sanction of the Committee of Lloyd's Register of Shipping. Any opinions expressed and statements made in this paper and in the subsequent discussion are those of the individuals.

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Discussion on Mr. G. Coggan's Paper

FIRE PROTECTION, DETECTION AND EXTINCTION IN SHIPS

(Printed without Author's replies)

Mr. T. A. Simpson

Our thanks must go to Mr. Coggon for this paper on fire protection, detection and extinction in ships, an informative and instructive document which, in my opinion, is long overdue and therefore doubly welcome at this period in time. It is well prepared and laid out, easy to follow and a credit to the Technical Association, the printers, as well as the Authors.

It is especially pleasing to me that this paper is one more link in a chain, prepared by members of the International Conventions Department, having as their ultimate main aim in view, the assistance of our outdoor colleagues in undertaking their survey work on board ships.

It follows the tonnage, safety equipment, crew accommodation and load line papers which I hope and believe have also all been of value to our colleagues at Headquarters and plan approval countries throughout the world in promoting a better understanding of the role that IMCO now plays, and will in my opinion continue to play, in the Society's activities.

There is no doubt in my mind that this particular paper will need constant updating and additions, and it is hoped that some means can be found in ensuring that this is done. It is not sufficient for classification societies to write their own rules nowadays, the decisions taken by national administrations having to be taken into account, especially in the field of safety and more particularly as it applies to fire protection, detection and extinction.

I agree wholeheartedly with the Author's very first sentence, in that the subject is vast, and hence the need for such a paper in view of the Society's heavy involvement in certifying compliance with the rules of those national authorities who have little or no marine administrative staff of their own.

Suffice it to say that prior to 1952, approval of fire plans was not within the mandate of many, if any, classification societies but when the 1948 SOLAS Convention came into force in that year, the future changed. The subsequent advent of the 'Flags of Convenience' countries further increased the Society's involvement in safety matters generally, so much so that at Headquarters alone, more than 3000 fire plans were dealt with during the year 1973.

In paragraph 3 . 1 . 3 (5) 'A' Class or fire resisting divisions, the Author makes reference to the possibility of the administration requiring a test of a prototype bulkhead or deck to ensure that it meets the stipulated standard for integrity and temperature rise. It will certainly be of interest to Surveyors to be made aware of where such establishments exist to carry out the required tests, and a basic idea of the procedures adopted.

In this connection is it usual for one administration to accept another's test procedures and results? Can material manufactured in the U.K. and approved and certificated by D.T.I. or L.R. for instance be automatically used on a Norwegian flag ship building in U.K. for L.R. Class without reference to the Norwegian authorities? The same question arises in the case of the low flame spread characteristic of laboratory tested material referred to in paragraph 3 . 1 . 6. Do differences exist in the categories 1, 2, 3 and 4 as applied by different administrations?

Due note should be taken of the final sentence of paragraph 3 . 2 where we are advised to anticipate new fire regulations for specialised ships such as car ferries, chemical carriers, gas carriers, fishing vessels, to name but a few. It makes one wonder where IMCO are leading us and how Surveyors are to absorb the additional work load, both physical and mental. Gone are the days when fire protection of ships was a subject needing little experience and knowledge, now a Surveyor is expected to have more than average knowledge of chemistry and physics, in addition to his normal qualifications as a Surveyor, and this paper therefore should be a great assistance as both a guide to his survey work and as a reference source.

I believe that more and more use will be made in future building, especially on passenger ships, of the prefabricated independent cabin accommodation unit system of construction, using incombustible material, constructed in the factory and slotted into the ship. In the cruise ship boom in the Caribbean this system is popular with the U.S.C.G. and as no ship irrespective of flag can pick up U.S. nationals as passengers without U.S.C.G. approval of the ship's arrangements, most large scale conversions and newbuildings use this relatively new, but highly efficient system. The Society has recently completed the certification of a new passenger ship built in Denmark for Greek owners which incorporates the best features of modern safety, including this system of accommodation, as do six large scale conversions now being undertaken in Greece.

It is noted from paragraph 3 . 4 that the crew spaces in cargo ships are now to be subjected to the IMCO treatment as for passenger ships. Does the Author think that this is really necessary, and do statistics prove the necessity? SOLAS 1960 accepts in its rule requirements that a passenger is more of a liability on a ship than an experienced sailor from a safety aspect. On a passenger ship it is expected that many women and children are carried together with more stewards who may not be expected to be 'seamen' in the true sense of the word. Surely the onus is on the shipowner to ensure that his officers and crew are fully trained fire-fighters and therefore fire conscious for their own safety. It is no good whatever providing all of the materials and apparatus to fight a fire if the crew have not been trained to use them.

Are owners really aware of what IMCO are contemplating? My own experience is that national authorities do not keep their owners and builders up-to-date with such matters, and it is therefore left to classification societies, L.R. in particular, to make themselves unpopular by bringing new rules and regulations to their attention, with the resultant innuendo that L.R. is too expensive. Too often the Society is blamed for having too rigid an approach to fire protection, detection and extinction matters when really we are endeavouring to advise in advance of what the national authority will require.

This situation is not helped by the reference in Chapter F, paragraph 102, of the Society's Rules where it states "Compliance with these statutory requirements (SOLAS 1960) MAY be accepted as meeting the requirements of this Chapter". I wonder how many times this three letter word has caused both the Society and its Surveyors embarrassment. Different emphasis on this particular word can change the whole intent

of the sentence, and therefore it is to be hoped that on the next rewrite of the Rules it will be made perfectly clear whether the national authorities' rules overrule the Society's Rules or not. In my opinion for a ship to be classed then it must comply with the Society's Rules. Perhaps the addition of an 'F' notation might meet the case where full compliance is obtained and, where say, domestic service only is involved and the national authority has its own rules for such cases, provided the Society is satisfied with the arrangements for the restricted service, then classification could be achieved, but without the 'F' notation.

At the present time it is not sufficient for Surveyors to think that because the national authority has approved the fire arrangements that classification will automatically be assigned. It is not uncommon for a national authority to accept the Society's criticism of their approval and reverse their previous decision.

May I endorse the comments of the Author in 5.3.1.2 regarding the position and arrangement of the emergency fire pump. The importance of this vital piece of apparatus is for some reason or other not always fully appreciated by Surveyors. Only last month one further ship was abandoned as a total loss on account of a fire in the engine room putting out of commission the main fire pumps and sufficient care had not been taken in siting the controls for the emergency fire pump which thereby became inoperable due to the same fire in the engine room.

I would particularly refer colleagues in Outports to the survey and fire procedures laid down in the Appendices. To my knowledge this is the first time an attempt has been made to regulate ideas on the subject. I feel this will be greatly appreciated, even if there are differences in opinion. The value of the paper will be greatly enhanced if there is a good response from Surveyors in the field.

In view of the implication of what is widely referred to as the 'Mini SOLAS 1974', I feel that the reference numbers of the IMCO Resolutions would, if tabulated, add to the value of this widely appreciated paper.

Again our thanks must go to the Author for this admirable effort—who knows it may result in beneficial changes in the Rules.

Mr. J. J. Wilson

I would like to congratulate the Author for a most interesting and informative paper and one which I am sure will be welcomed by our colleagues in the Outports as well as by H.Q. technical staff.

We are all aware of the damage to property and sometimes loss of life which may result from fires and we are all concerned to see the fire risk aboard ships reduced to a minimum. Despite an increased awareness of this danger in the past few years, and the efforts made to reduce this risk, we still learn of fires aboard ships, and when they occur on vessels that are well known they make headlines in the national press.

Most people have a good idea of how fires occur and a general concept on how they are extinguished, although many would simply conjure up a vision of a fireman with a hose pouring water into a building in flames. Unfortunately, too many people, including shipyard and seagoing personnel, are inclined to believe that serious fires occur only aboard other ships which are someone else's responsibility.

I remember when a fire broke out in the boiler room bilges aboard the second ship I served in. I was a very inexperienced fourth engineer at the time and when I reached the boiler room there was quite a serious oil fire raging on the tank top under one of the boilers. We tried at first to extinguish the fire with portable extinguishers. Some required to be turned upside down, with others the plunger had to be depressed, or we had to remove a pin and grip a handle. There is little opportunity to read operating instructions at such a time, so I would suggest that when possible all portable extinguishers aboard a ship except those required for a specific duty, should be of a similar type.

Despite our efforts with portable extinguishers the intensity of the fire increased and it is fortunate that one of the senior engineers thought to use the steam smothering system, and perhaps more important, knew where the operating valve was situated. The fire was extinguished before any serious damage was done but the adage 'know your ship' has remained in my memory since. There was no foam system, CO_2 installation or even spray water nozzles aboard the ship so far as I can remember, so had the steam smothering system proved ineffective the ship may have become a total loss.

Incidentally, possibly because of this personal experience I have always paid particular attention to fire extinguishing arrangements at surveys, and especially to testing steam smothering arrangements when this was required to be done. Prevention is always better than cure, as Mr. Coggan has emphasised, and this is particularly the case in respect of fire hazard aboard ships.

In the Refrigeration Department we are required to approve various kinds of insulating materials for use in classed refrigerated cargo holds and chambers. At one time the material selected was usually either mineral wool or slab cork, both fitted behind a protective lining and the fire risk was very slight. However, with the advent of plastic foams, particularly polyurethane, we not only have a variety of materials being submitted for approval as insulants but there are nearly as many different grades of rigid foams as there are manufacturers.

Most of these materials are excellent insulants, they have a very low thermal transmittance rate, are almost impervious to moisture, are lightweight, easy to fit, can have almost an unlimited life without attention and would appear to be the answer to all our insulation problems. When these rigid foams first came to our notice and we questioned their fire risk we were assured that the types we were being asked to approve were 'self-extinguishing' and 'flame retarding' and test results we were shown seemed to indicate that this was the case. However, after one or two fires in shipyards where polyurethane foam was being fitted as an insulant, in connection with refrigerated cargo installations, we considered it expedient to reappraise the fire hazard and test procedure in relation to this and similar materials.

Naturally we were not alone in our concern that these so-called 'self-extinguishing', 'fire-retarding' materials were not what we had been led to believe. Tests which had been accepted internationally as indicating whether a material could be graded as 'self extinguishing', were now known to give results which, to say the least, were misleading. Materials which are in fact 'self extinguishing' when small samples are tested in a laboratory will continue to burn fiercely when large exposed areas of the same material are ignited.

These foams are now applied 'sprayed-on' and 'foamed *in situ*' as well as in rigid slabs, etc., and when used for insulating refrigerated holds or chambers the foam should be reasonably protected from any source of ignition, preferably behind a

metal lining. When behind a lining the fire risk is reduced considerably but I would like to take this opportunity to stress to my colleagues that the greatest fire risk with this material does not occur when the ship is in service but during construction or when being repaired, particularly before the lining has been fitted or when removed in order to effect repairs to the insulation or steel structure in the vicinity. There may still be shipbuilding and shiprepair personnel that think so-called 'self-extinguishing' polyurethane does not present a very great fire risk and I wonder whether Mr. Coggan might consider it advantageous to include extracts from the D.T.I. 'M' Notice No. 592 as an additional appendix with his reply to the discussion on this paper.

I should perhaps mention that there is a new generation of rigid foam insulants becoming available with a considerably reduced fire risk, but they are expensive and not in general use.

I would like to refer very briefly to the use of inert gas as a means of reducing fire risk. Aboard liquefied gas carriers certain hazardous spaces adjacent to the cargo tanks may, under service conditions, contain inert gas. If these spaces, or in fact any enclosed space, tank, duct keel or cofferdam has to be inspected, before the space is entered it should have been well ventilated for some time and preferably declared fit for a person to enter by a competent officer, before any attempt is made to carry out an internal examination. A certificate is sometimes issued stating that a space is 'gas free' or does not contain flammable vapour. This does not necessarily imply that the space contains an atmosphere that will support life. Further, there may be pockets of gases which are deficient in oxygen, between deep frames, etc., even when a space has been ventilated for some time. Only last week three experienced senior ship's officers were aphyxiated when they entered what they apparently considered to be a well ventilated space which had previously contained inert gas.

Finally, I congratulate Mr. Coggan again on his paper which shows that fire protection, detection and extinction in ships, covers a wide range of disciplines, and anyone reading the paper will have a much better understanding of this important subject.

Mr. J. ROBERTSON

This is not the first paper presented to the Technical Association which deals with fire but it is the first to deal with the subject comprehensively. I think it will achieve the aim expressed in the first paragraph of the introduction as not only is there a wealth of useful information in the body of the paper but the appendices should prove of great value to colleagues everywhere.

There are a number of aspects of the paper on which I would like to comment and the first of these concerns 'B' Class fire retarding divisions.

In Section 3 . 1 . 4 emphasis is placed on the definition of non-combustible 'B' Class divisions and an impression may be created that combustible 'B' Class divisions are not often encountered nowadays. Regrettably, this is not the case and the use of combustible 'B' Class material is still regularly encountered. In fact, in Japan, chipboard is used for this purpose almost exclusively.

It should be noted that the 1960 SOLAS Convention requires combustible 'B' Class divisions to be Class B30 the additional insulation value presumably being intended to provide some compensation for the combustibility of the material.

In Section 5 . 2 . 8 reference is made to the cautious acceptance being given to HALON 1211 and 1301. A number of national authorities and classification societies have now accepted in principle the use of HALON 1301 in fixed installations for machinery spaces and oil tanker cargo pump rooms. Lloyd's Register is amongst these and has approved plans for a HALON 1301 system to be installed in a series of oil tankers for Shell. A surveyor from the Fire Section of I.C.D. has attended commissioning tests being carried out on the first installation. The Fire Section is also dealing with an increasing number of enquiries about HALON installations.

In view of the increasing acceptance being given to Halons, I think it would be of interest, and a useful addition to this paper, to have Mr. Coggon's views on the general requirements for such installations. HALON 1301 has gained more acceptance than 1211 for marine fixed installations and Mr. Coggon's views on the future of 1211 and indeed 1301 in this field would be appreciated.

In spite of modern developments in extinguishing methods the fire main remains the most important extinguishing system on board a ship and is a Rule requirement on all but the smallest craft. Section 5 . 3 . 1 will, therefore, repay special attention. With regard to hoses and nozzles, I think that the present international regulations fail to take advantage of modern developments by not making mandatory the smaller diameter hoses and also nozzles similar to that shown in Fig. 8. Meanwhile their increased use is to be encouraged.

I now pass to the next point which concerns Section 5 . 3 . 7 dealing with inert gas systems.

The action of inert gas systems in oil tankers can be compared with immunisation in medicine. Nothing is required to be done to remove the ignition sources and complete reliance is placed on having an inert atmosphere in the cargo tanks at all time so that explosions cannot occur. If the system fails immunity is lost. Therefore, to be effective, an inert gas system has to be reliable. This means very high initial and maintenance costs. Running costs too are high as the system is in continual use.

I would like to have Mr. Coggon's views on this aspect of inert gas systems and whether he thinks there are any more economic alternatives which could be developed to give an equivalent degree of protection.

I have in mind the cargo pump room explosion suppression system which is due to be tested later this year on board the T2 tanker *Rhode Island* operated by the U.S.C.G. for testing extinguishing systems. Rather ominously, I understand that it is planned to scrap the *Rhode Island* after the completion of these tests or, according to some, perhaps even before.

The tests will consist of a series of explosions initiated electrically in the pump room which has a volume of about 20 000 cubic feet. The pump room atmosphere will consist of a homogeneous stoichiometric mixture of petrol and air which constitutes the most severe condition under which an explosion could occur. It is planned to test HALON 2402, 1211, 1301 and water as suppression agents. The suppression system will be activated by the initial pressure wave generated by the explosion and total suppression should take place in about 1/20 part of a second.

Such systems have been used with a high degree of success in industrial processes where there is an explosion risk, but I believe this is the first attempt to use the system on board an oil tanker.

Finally, I wish to comment on the number of firemen's outfits required. In Section 5 . 5 . 1 it is stated that the number of firemen's outfits varies according to the tonnage of the ship. In fact the 1960 SOLAS Convention requires only one or two outfits to be provided for cargo ships depending on the tonnage. The situation for passenger ships is a little better, but in my opinion neither type of ship is adequately provided for.

In view of the heavy smoke logging which can occur in enclosed spaces on board ship, it is my view that at least eight outfits should be provided, sufficient to equip two fire fighting parties. Each outfit should contain a self contained compressed air breathing apparatus. Two spare cylinders should be provided for each apparatus and a compressor for recharging the cylinders should be carried on board. This will give the opportunity for the crew to practice the use of the breathing apparatus whilst an adequate supply of fully charged air cylinders would be available in a fire situation.

I would like to conclude by thanking Mr. Coggon for the considerable time and effort he has devoted to the writing of this paper which I am sure will be appreciated by colleagues throughout the world.

Mr. J. R. G. Smith

Surveyors will find this paper an authoritative standard reference on fire protection, detection and extinction in ships and it will enlighten many as to the scope, complexity and importance of this particular subject.

I would like to ask the Author three questions concerning aspects of this work.

(1) Why do the Rules not contain more specific requirements for the drainage of water pumped into the ship for fire fighting purposes?

As far as I know the only specific requirement in the Rules concerns the drainage from vehicle decks on car ferries when drencher systems are fitted, and even this only calls for additional scuppers with no special provision for pumping out. At the moment, as long as the minimum Rule requirements for bilge pump and fire pump capacities are satisfied, the fire pump capacity could be many times that of the bilge pump capacity. Under such circumstances, of course, a ship fire could indeed be extinguished by sea water, but the ship would be completely immersed in it.

(2) Why are so many fire protection requirements related to gross tonnage?

This would be feasible if the same tonnage regulations were recognised by all national authorities. However, at the moment it is possible for exact sister ships to have very different gross tonnages dependent on their flag. In fact in a recent case, structural fire protection was not required on a ship registering in Panama as the gross tonnage was less than 4000. The tonnage had been measured in accordance with the tonnage mark scheme, according to normal Panamanian practice. Shortly before delivery the registration was changed to Mexican. As Mexico has not ratified the tonnage mark scheme, the tonnage was re-computed in accordance with the pre-1965 international tonnage regulations in accordance with normal Mexican practice. The previously exempted large 'tween deck spaces were now added back into the gross tonnage which now became in excess of 4000 and, according to the Rules, structural fire protection was now required. Same ship, same fire hazards, different tonnage regulations, different structural fire protection requirements! The primary fire extinguishing system on ships, namely the fire main, is based on the length, breadth and depth of the vessel, and I see no reason why all fire protection requirements could not be based on the same parameters.

(3) Why are the Society's requirements for means of escape contained in Chapter D?

I imagine it is because means of escape are necessary in the event of any ship disaster and not only in the case of fire. Nevertheless, in my view, if means of escape were considered and approved from the fire aspect, such means would then be acceptable for all other contingencies. I would propose therefore that the requirements for means of escape be included in Chapter F with a suitable cross reference in Chapter D.

Finally, I would like to thank the Author for the considerable time and energy he has spent in the preparation of this paper and I am sure my appreciation will be shared by colleagues throughout the world.

Mr. G. Smart

I would like to add my congratulations to Mr. Coggon for this informative and much valued paper which is long overdue, as little or no information has, so far, been published on this most important and fascinating subject.

Only those members of the Surveying Staff who have attended the Mercantile Marine Fire Fighting Course at McDonald Road Fire Station in Edinburgh can fully appreciate the appalling conditions to be experienced in the event of a fire on board ship.

It is unfortunate that the inexperienced, in their ignorance, look upon fire-fighting as simply approaching the fire and merely putting it out with a squirt of water. This, unfortunately, is not the case. It must be remembered that fire is accompanied by a very discomforting heat, humidity, smoke and furthermore, in many cases, complete darkness is a dull companion. One must also imagine being hampered by a breathing apparatus and, having experienced such conditions personally, I can only say that they are, to say the least, almost unbearable.

It is agreed that this subject is indeed vast and I appreciate that the Author has been hard pressed in the preparation of this paper due to other commitments, but hope that colleagues will be kept fully informed of the latest developments with regard to fire protection, detection and extinction in ships.

There is no doubt that fire at sea is the hazard most dreaded by the seafarer and, following the loss by fire of the passenger liner *Lakonia* in 1963, there was a distinct drop in cruising activities due to thousands of members of the public refusing to set foot aboard a passenger ship because of the fear of being involved in a fire at sea.

Accommodation space fires are probably the most common of the fires occurring on board ship but are generally of a minor nature and easily controlled. However, over the past few years, several fires which have started in the accommodation spaces of passenger and cargo ships have resulted in vessels being lost with heavy loss of life in some cases.

The most usual case of accommodation fires is the habit of smoking in bed. Although most people know that this action has cost the lives of many others, they still believe that they could not make such a mistake as to fall asleep whilst smoking. Furthermore, there is little doubt that many serious fires which have occurred could have been controlled at an early stage if the person or persons responsible for the

outbreak, or those who were first on the scene, had taken elementary precautions instead of fleeing from the spot in panic and seeking their own way of escape.

Many fires have originated in ships' galleys, generally because of overheated pans of fat catching fire which has also been the cause of many fires in dwelling houses and hotels. It must be realised that a pan of fat left unattended on a lighted burner will eventually reach auto-ignition temperature and burst into flame. People have sustained serious burns while carrying the flaming pan outside through an open doorway or trying to extinguish the flames by the application of water. Obviously, these methods are extremely dangerous and should not be attempted, the proper way is to remove the pan from the source of heat and cover it with a lid or damp cloth to smother the flames.

In addition to fires in living quarters, the increased use of electrical power, the complicated electrical machinery in a modern ship and high voltages have brought electrical fire risks to life on board, while for many years, cargoes such as jute, cotton, wool and coal have given rise to fire due to spontaneous combustion.

In Section 5.2.2 the Author describes the use of steam as a fire extinguishing agent. It might be added that the regulations permit the use of steam as a smothering agent in cargo spaces of new ships, provided the boiler or boilers available for supplying steam have an evaporation rate of at least 1 lb of steam per hour for each 12 cubic feet (1 kg. for each 0·75 cubic metres, of the gross volume of the largest cargo compartment. It is also required that steam will be available immediately and will not be dependent on the lighting of the boiler or boilers and that it can be supplied continuously until the end of the voyage in the required quantity in addition to any steam necessary for the normal requirements of the ship including propulsion and that provision is made for extra feed water necessary to meet this requirement.

This implies that an independent steam supply together with additional feed water, is necessary if a steam smothering system is to be installed and, as this is not economical from the owner's point of view, the use of this type of system in new ships has, so far, been avoided.

Steam, being lighter than air, makes it suitable for fires near the top of the compartment but is relatively ineffective for fires which are low down. When steam is first admitted into a compartment there is likely to be considerable condensation causing a partial vacuum. Air may be sucked in to make the fire burn more fiercely in the initial stages.

Steam must not be used in compartments containing explosives, coal or substances which react dangerously with water. Considerable cargo damage may be caused by condensation and certain commodities, such as grain and wood pulp, swell when steam is applied.

It might be added that steam is not acceptable as an 'alternative means' of extinguishing machinery space fires in existing ships.

Whilst on the subject of fire extinguishing agents, it is considered relevant to mention the special requirements of the National Cargo Bureau, of New York, concerning the fire extinguishing apparatus in motor and steam vessels carrying cotton. I, therefore, request the Author to give details of these Regulations.

On the subject of dry powder extinguishers, many existing ships, built in Germany, Holland and Scandinavia will probably have the majority, or all, of extinguishers of the dry chemical type. In these cases it is concluded that the existing arrangements will be accepted when these vessels transfer Classification or flag, but the Author's confirmation would be appreciated.

Mention is made in the paper of the emergency fire pump and I would like to take this opportunity of stressing that experience shows this to be one of the most neglected items on board ship. If the emergency fire pump fails to operate, this becomes a condition of Class and it is essential that efficient temporary arrangements be provided in accordance with Circular No. 2296.

An ideal combined jet/spray nozzle with shut-off valve is illustrated in Fig. 8. Having used this type of nozzle in practice, I can only describe it as being ideal for fire-fighting purposes. Unfortunately, no Rules or regulations call for this type of nozzle and we must contend with the plain jet or combined jet/spray type which necessitates the attendance of a second person at the hydrant to turn on the water.

It is somewhat relieving to note that hoses less than 64 mm ($2\frac{1}{2}$ in) diameter are now considered preferable. Experience shows that the handling of a $2\frac{1}{2}$ in hose under pressure is impossible by one man and the smaller hose is by far superior.

Referring to carbon dioxide systems, the Author mentions the testing of the distribution manifolds and the pipes between the cylinders and manifolds. This guarantee of test is of the utmost importance as a serious mishap occurred recently when the manifold pipe connections failed and allowed the smothering gas to escape accidentally. Carbon dioxide entered the accommodation and unfortunately two men died as a result.

With reference to deck foam systems on a ship with rounded topsides, it is felt that there is every possibility of a layer of foam on the deck being blown overboard except in very calm conditions. I would appreciate the Author's comments on the likelihood of this occurring.

Before leaving the subject of smothering systems, it is known that several Russian-built vessels have fixed systems charged with ethyl bromide. Whilst this type of system has been the subject of Circular Letter ICD/ICL 18 dated 13th July, 1973, I would like the Author to make mention of this in the discussion for the benefit of colleagues who might be involved in the inspection of such a system and the precautions to be taken.

With regard to firemen's outfits, whilst the Society's Rules do not ask for protective clothing, it is important to note that all new and existing ships registered in Israel, Liberia and Singapore now require, for each firemen's outfit, a complete set of protective clothing. Furthermore, the number of outfits required now varies and a Circular Letter on this subject is being prepared.

It might also be mentioned that each self-contained breathing apparatus is to be provided with fully charged spare cylinders having a storage capacity of at least 2400 litres of free air. Looking at illustration, Fig. 14, I might add that the lifeline should be attached to the apparatus by a snaphook, not by a spliced eye or shackle.

In conclusion, it is thought appropriate to finally stress that the utmost vigilance is required of the Surveyor when carrying out a survey of fire appliances. Failure to extinguish a fire in its early stages may result in loss of the ship and the lives of those on board. It is therefore essential that all fire appliances are in efficient condition and available for immediate use in case of an emergency.

MR. T. R. FARRELL

My congratulations also to Mr. Coggan. I will confine my comments to a request for further information on the use of halogenated hydrocarbons for fire extinguishing. Can the Author indicate the sizes and types of spaces for which they are most suitable? Some particulars of any approved installations and the Author's comments on the reported use of ammonia to 'kill' toxic gases would also be appreciated. Finally, do these products represent a breakthrough in effective 'total flooding' systems which may be suitable for use in occupied spaces?

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Lloyd's Register Technical Association

SURVEYING O.B.O's AND LARGE BULK CARRIERS

G. S. McIntosh

Paper No. 2. Session 1974-75

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SURVEYING O.B.O's AND LARGE BULK CARRIERS

by G. S. McIntosh*

TABLE OF CONTENTS

Section 1 . 0 Introduction

Section 2 . 0 Shipyard Layout

Section 3 . 0 Preparation

Section 4 . 0 Panel Line Assembly

Section 5 . 0 Sub-assemblies

5 . 1 Points of interest

Section 6 . 0 Erection on Berth

6 . 1 Difficulties encountered

Section 7 . 0 Fitting Out

Section 8 . 0 Delivery

Section 9 . 0 Conclusions

Acknowledgements

Bibliography

Appendix 1 Sequence of Operation

Appendix 2 List of Certificates

1 . 0 INTRODUCTION

Clearly, with the rapid change that is taking place in industry today it is almost impossible to forsee where the Society should be heading or what role Ship Surveyors in general will be required to fill in the future, whatever the individual's own role may be. However, it is vitally important that Lloyd's Register should maintain its place at the head of the classification field, and this can only be achieved by providing the highest service possible to the shipbuilding industry.

With the introduction of new techniques and standards the ship owner and shipbuilder will only seek the services of Lloyd's Register of Shipping if they feel that it is providing a worthwhile contribution to the industry. To do this, field Surveyors must be fully equipped in theory and practice, to deal with the everyday problems in the industry.

To meet the challenge of the technological age it has been necessary to recruit an entirely new type of entrant to the Society. In Britain, for instance, due to the present-day structure of University and Polytechnic training, new entrants may be very well versed in the theoretical side of naval architecture, but may have very little experience of the practical aspect of shipbuilding. Their theoretical knowledge is seldom directed along the lines necessary to make a competent all-round Surveyor, and some experience in the various departments at headquarters, especially plan approval so far as new construction is concerned, will make it easier for them to assimilate the practical side of the work when eventually they are sent to an outport for practical instruction from an experienced Surveyor. However, the above arrangement is not always possible, and Surveyors can find themselves responsible for looking after the Society's interests in a shipyard after a comparatively brief period.

While the Society has an excellent system for recording faults, defects and failures on ships in service, which was previously illustrated in a paper by Gibbs and Boyd in 1958, there would appear to be a need for a similar arrangement for recording defects and difficulties encountered by Surveyors during the construction of new ships.

With these thoughts in mind, it is sincerely hoped that the following notes of experience gained in the construction of ore/bulk oil carriers and large bulk carriers will help towards this end and may be of interest to the new recruits and younger members of the Society.

Due to the ever increasing need for interchangeability between Ship and Engine Surveyors and the expansion of the Specification Services Department, it is hoped that the contents of this paper may also be of benefit to Engine Surveyors who find themselves engaged on ship surveys and that other Surveyors on new construction will contribute their experiences to the discussion.

2 . 0 SHIPYARD LAYOUT

Shipyards throughout the world can vary in size and layout depending upon the type and size of ships being built there. Fig. 1 indicates a typical layout of a shipyard producing large ships. It is not meant to represent the ideal arrangement nor are the spaces indicated necessarily in proportion to the area required, the intention being to illustrate only the systems employed.

3 . 0 PREPARATION

This covers all aspects of specification, design, plan approval, steel delivery, rolling, shot blasting, paint priming, marking and checking.

The Surveyor should have the opportunity of examining working drawings of panels to be fabricated, at an early stage, to satisfy himself that all cut outs, scallops and manholes are shown and have been included in the computer tapes for numerical control burning. Hand burning at a later stage is always expensive and inferior to numerical control burning and should be kept to a minimum. The Rules require all cut-outs and scallops at shell and main deck plating to be smooth. Further, cut-outs in longitudinal high tensile steel members should be of elliptical form. If such cut-outs are not included in the original program for numerical control burning, they may be required to be burned by hand which will require careful dressing to avoid any notch effects.

It has been found that a great deal of trouble can be avoided if all material is carefully examined for latent laminations and surface defects after shot blasting. It is never advisable to be hasty in rejecting defective material and a

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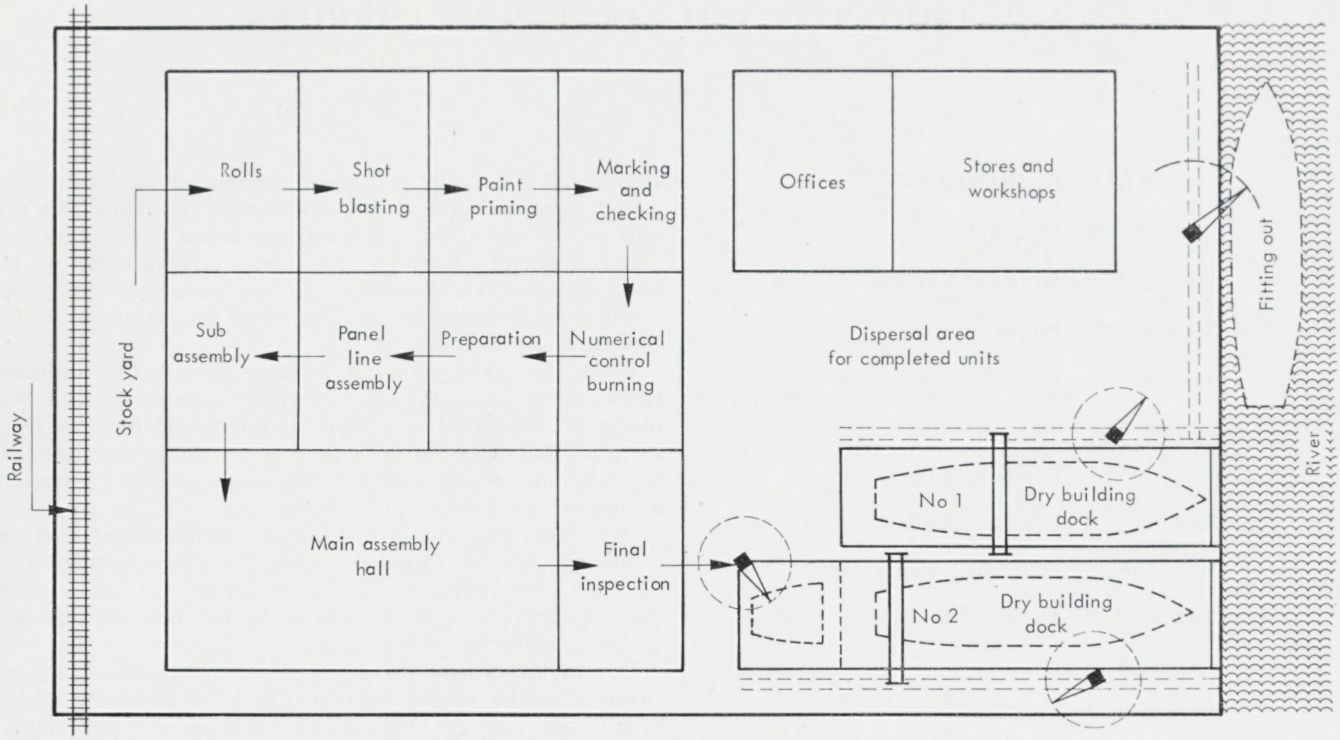


FIG. 1

Schematic of shipyard layout.

final decision should not be made before the following points have been considered: —

(1) The position where the plate or section is to be used.

(2) Does the nature and extent of the defect warrant renewal?

(3) The time required to receive a replacement.

(4) Is the production likely to be held up?

(5) Will the Owner's representative accept part renewal or repair by welding or grinding?

The owner must always be considered, but providing the work is correctly carried out there is no reason why the material may not be cropped and part renewed. The procedure to be adopted in dealing with welded repairs to defective material is clearly laid out in *Instructions to Surveyors,* Part 8, 1971, Welding of Ships.

It is important that paint priming should be carried out directly following shot blasting. On occasions it has been found that the coatings dry unevenly leaving a mottled effect on the steel. Rollers may also cause damage to the paint as the plates are conveyed to the panel line. All defective paint should be recoated immediately. On a recent ship it was found that large areas of white powdered salt appeared on the external surfaces of the shell plating after weathering. It was stated by the paint manufacturer that this salt was probably due to either improper mixing or air pollution. All such areas must be washed clean with fresh water and thoroughly dried before applying the next coat of paint.

Careful inspection at the panel line may well avoid serious loss of time and expense at a more crucial stage. Shipbuilders are becoming more and more aware of the importance of a well organised quality control team in the shipyard. This department is responsible for inspection at every stage also for carrying out dimensional control of fabricated units before erection. Shipbuilders may argue that it is essential for quality control and dimensional control to come directly under the control of the Production Department, but to be really effective, it should be an independent department. Where this is the case, the Surveyor should form a close liaison with the team and lend all assistance possible. As the quality control system develops and begins to prove its value, it is evident that examination of all fabricated units by the Surveyor may be relaxed and replaced by daily inspection of selected units.

4. PANEL LINE ASSEMBLY

(1) Numerical control tapes should be programmed so that the burning of notches which occur at the beginning and end of the runs are clear of the final outline.

(2) Tack welds should be kept to the minimum necessary to effectively hold the work.

(3) Incorrect fit-up of members should be avoided.

(4) Automatic welding processes are particularly dependent upon correct fit-up. A common fault found where longitudinals had been welded by an automatic twin head machine was for the weld deposit to adhere to the longitudinal web only, with little or no connection to the flat surface.

(5) Where gravity feed welding is used, it is generally found that the tendency is for the weld deposit to fall on the horizontal surface giving an unbalanced leg. This can be improved by correct setting of the angle of the rod.

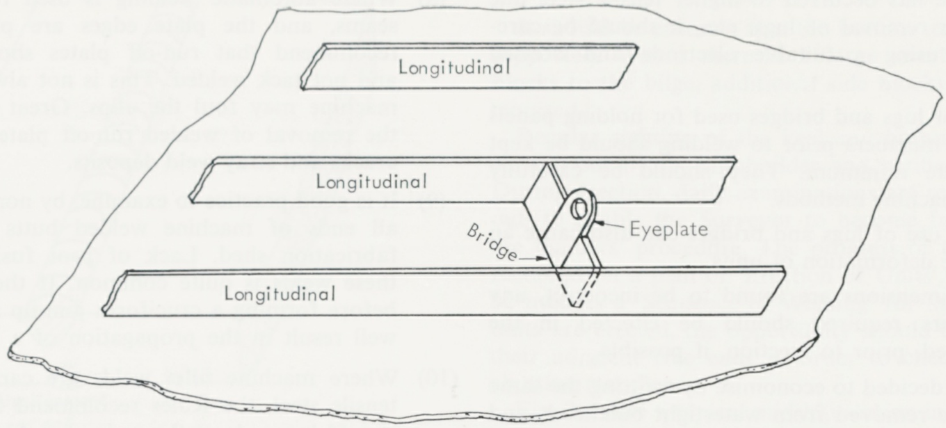


FIG. 2

Unit lifting arrangement.

(6) With both automatic and gravity feed fillet welding, it is necessary to complete all ends by hand, at scallops and notches. This often leads to cavities and under-cut welds at these points.

(7) If the automatic welding machine has been stopped during a run and likewise at the change over of gravity feed electrodes, excessive build-up or cavities may result.

(8) Where members are to be aligned at the berth such as transverse bulkhead webs at the top and bottom shelf plates, it is advisable to indicate on the dividing plate the position and thickness of the abutting members to ensure alignment with members on the opposite side.

(9) Where any material is required to be cropped and part renewed due to bad fit-up, it should be brought to the Surveyor's notice before repairs are effected.

5.0 SUB-ASSEMBLIES

Unit inspection prior to erection is the accepted practice in most shipyards and should be initially carried out by the shipyard quality control personnel and only when the unit is considered to be complete should the Surveyor be requested to carry out his inspection. The shipbuilder is responsible for the presentation of the units. It must be borne in mind that the Surveyor has not much time to spend on unit examination in view of the numbers involved.

It is in the interest of the shipbuilder to submit a list of 'Standard Details and Tolerances' for approval and the Surveyor should co-operate with the quality control team to see that they are implemented. This has been extended by some shipyards to include a system of demerit rating where defects are credited with a points rating, dependent upon their importance. A number of variables need to be taken into consideration such as, position, type of material, primary or secondary member, type of weld, depth and extent of serration, etc. In this manner the quuality control team may determine a points level for units where special action should be taken by senior management or, if necessary, when a unit may be required to be removed from the assembly line.

5.1 Points of interest

(1) In panel line assembly and unit fabrication stage, the maximum use of magnetic lifting methods should be used. When lifting units, lugs should not be welded in the middle of unsupported panels of plate (*see* Fig. 2). If this is unavoidable, then the panel of plating in way of the lifting eye should be bridged. An alternative arrangement which has been proved successful is shown in Fig. 3. With this method no welding is required, the unit is lifted by a portable pin which is fitted through the drain holes or erection holes in the secondary members. The same apparatus can be used many times.

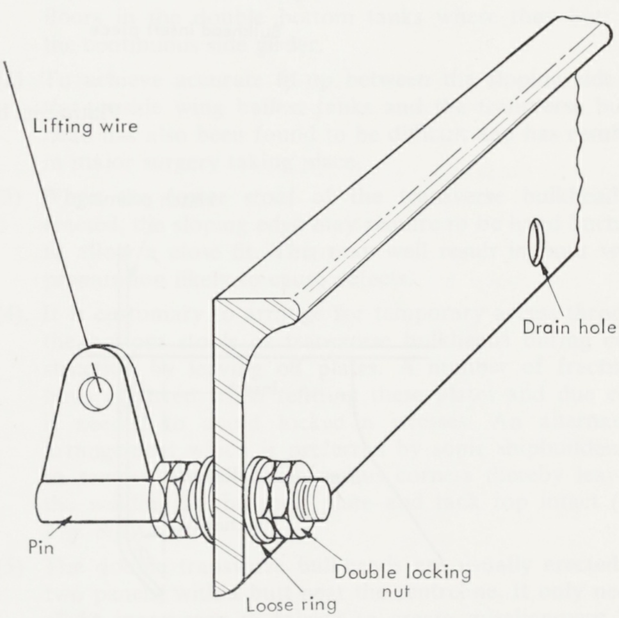


FIG. 3

Unit lifting arrangement.

(2) Where damage has occurred to higher tensile steel due to the careless removal of lugs, etc., it should be carefully welded using a suitable electrode and dressed smooth.

(3) The number of lugs and bridges used for holding panels and stiffening members prior to welding should be kept to an absolute minimum. They should be carefully removed by machine methods.

(4) The excessive use of lugs and bridges can also cause an increase in the deformation of units.

(5) Where unit dimensions are found to be incorrect, any welding repairs required should be effected in the fabrication shed, prior to erection, if possible.

(6) A shipbuilder decided to economise by refitting the same pieces of plate removed from watertight bulkheads and floors where longitudinals pass through (*see* Fig. 4). Great difficulty was encountered in replacing these pieces, as inserts, without fractures occurring in the weld. The usual method of fitting lapped collars was finally reverted to.

(7) A similar difficulty was met where the continuous hatch side girder was slotted through the transverse bulkhead top stool. Again, bulkhead insert pieces showed a high incidence of fractures, most of which probably resulted from poor fit-up (*see* Fig. 5).

(8) Where automatic welding is used for panel butts and seams, and the plate edges are prepared, the Rules recommend that run-off plates should be clipped on and not tack welded. This is not always possible as the machine may foul the clips. Great care is required in the removal of welded run-off plates to avoid cavities, cracks and stray weld deposits.

(9) It is good practice to examine, by non-destructive means, all ends of machine welded butts and seams in the fabrication shed. Lack of root fusion at the ends of these welds is quite common. If they are not repaired before forming a cruciform join-up at the berth, it may well result in the propagation of a serious fracture.

(10) Where machine fillet welds are carried out on higher tensile steel, the Rules recommend that random checks should be made at the ends of welds by non-destructive means. Some shipyards prefer to select certain longitudinal members and examine the fillet welds over their complete length. With this method, transverse cracking across the welds has been found which might otherwise have been missed.

(11) Where UNIONMELT machine or deep penetration welding is used, it is important to carry out a visual examination, both along the length of the weld and at its ends, in order to check the alignment (*see* Fig. 6).

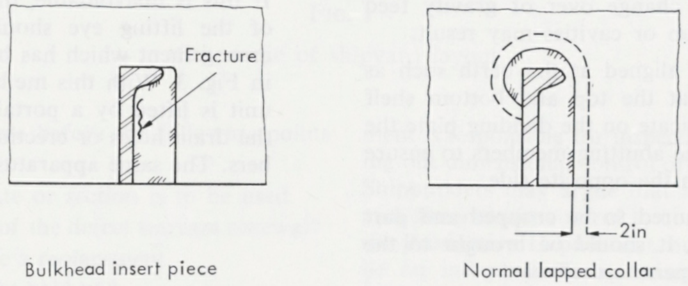


FIG. 4

Plating-in bulkhead notches.

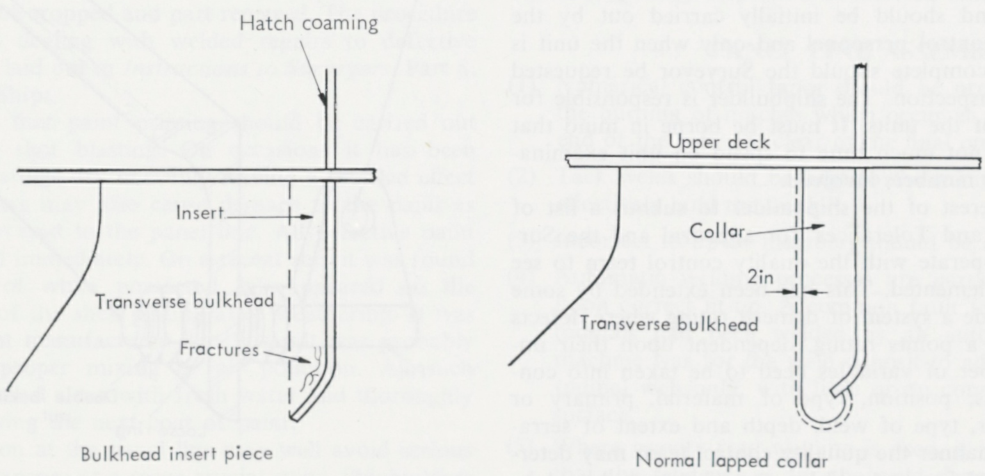


FIG. 5

Plating-in longitudinal girder bulkhead notch.

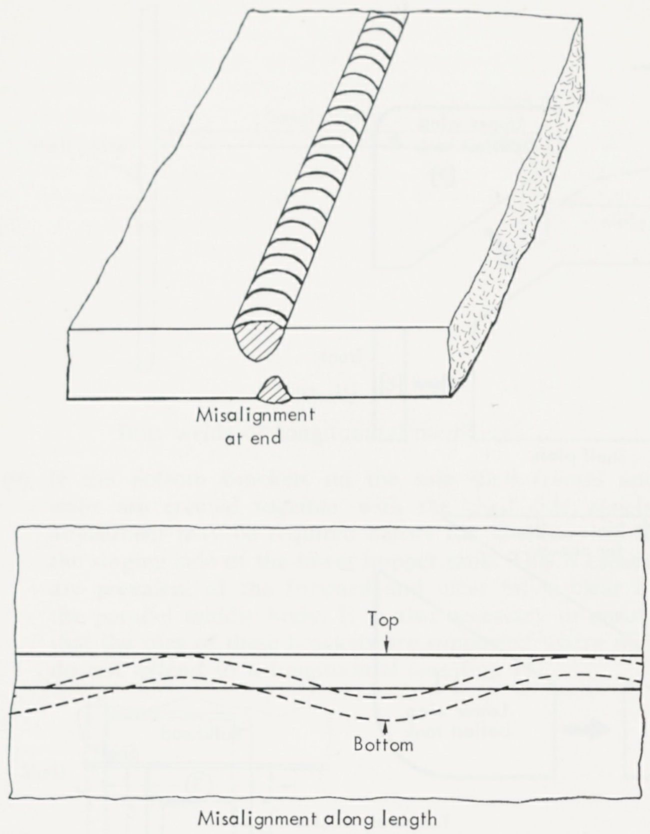


FIG. 6

Weld misalignment.

(12) With UNIONMELT welds there is a tendency for the machine to blow through at the beginning and ends of seams. This can be improved by preparing the edge of the run-off piece in reverse to the plate edge preparation (*see* Fig. 7).

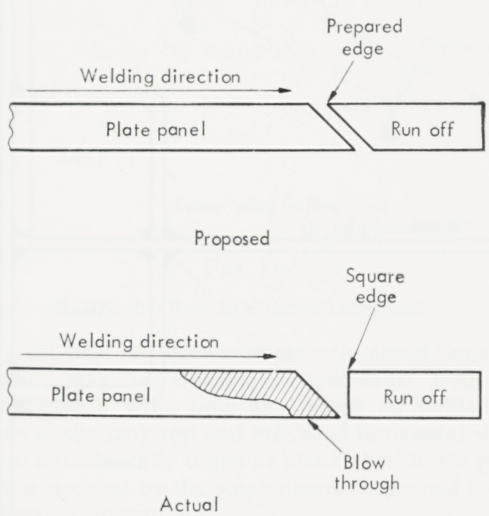


FIG. 7

Blow-through at ends of welds.

6.0 ERECTION ON BERTH

It should be ensured, that the bottom structure is adequately supported. Where there is a large overhang from the keel blocks to the bilge, additional side blocks and shores may be required.

Regular sighting of the keel and bottom structure is to be carried out by the shipbuilder and verified by the Surveyors. During erection, daily examinations are required to be carried out, to enable the Surveyor to become fully conversant with the builders' procedure. The progress of the ship is generally recorded on a plan of 'Erection of Units'. This plan may also be used as a 'Sequence of Welding' for main structure. When units are erected, the opportunity should be taken to examine their adjacent free ends in order to check the alignment of abutting members.

Fig. 8 shows a typical midship section in way of a transverse bulkhead, from which can be seen the break-up on units, as follows: —

[1] Double bottom structure.
[2] Lower wing ballast tanks (p & s).
[3] Lower stool of transverse bulkhead.
[4] Transverse cellular bulkhead.
[5] Top stool of transverse bulkhead.
[6] Side shell plating (p & s).
[7] Topside wing ballast tanks (p & s).
[8] Cargo hatch coaming and deck in way.

6.1 Difficulties encountered

The following examples may help to illustrate some of the problems encountered over the last few years, on the construction of large ships. Items Nos. 1–6 refer to corresponding numbers on Fig. 8.

(1) A recurring defect has been the misalignment of transverses in the lower wing ballast tanks and the transverse floors in the double bottom tanks where they butt on the continuous side girder.

(2) To achieve accurate fit-up between the sloping side of the topside wing ballast tanks and the transverse bulkhead has also been found to be difficult and has resulted in major surgery taking place.

(3) When the lower stool of the transverse bulkhead is erected, the sloping edge may require to be hand burned, to allow a close fit. This may well result in poor weld preparation likely to cause defects.

(4) It is customary to arrange for temporary access through the bottom stools of transverse bulkheads during construction by leaving off plates. A number of fractures have occurred when refitting these plates and due care is needed to avoid locked-in stresses. An alternative arrangement which is preferred by some shipbuilders is to remove a panel with radius corners thereby leaving the welding at the shelf plate and tank top intact (*see* Fig. 8(a)).

(5) The double transverse bulkheads are usually erected in two panels, with a butt near the centreline. It only needs slight inaccuracy in fairing to create misalignment between the webs of the cellular bulkhead and the webs of the bottom stools where they abutt on the lower horizontal shelf plate.

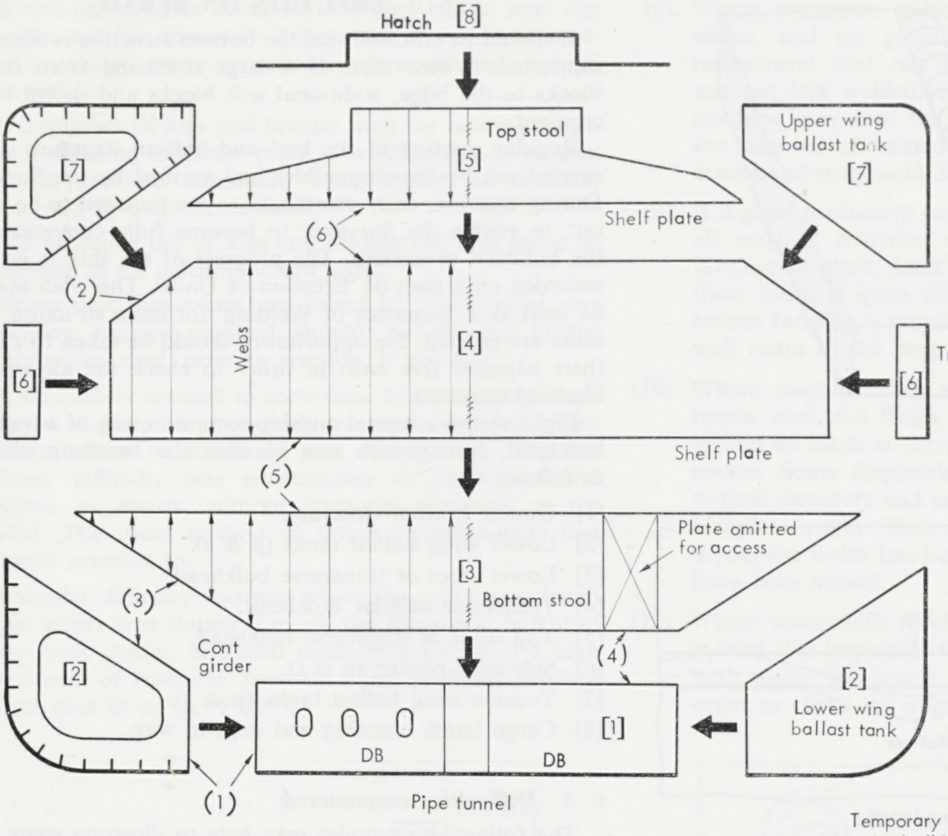
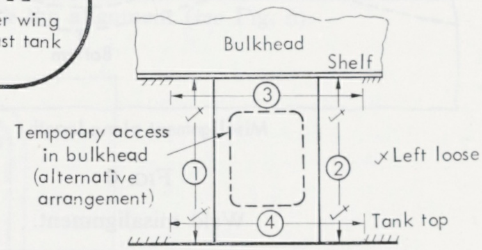


FIG. 8

Sequence of erection and areas of common defects.



Welding sequence in way of access hole.

FIG. 8(a)

(6) Similarly, between the top stool and transverse bulkhead webs, misalignment very often occurs at the upper horizontal shelf plate.

(7) The connecting trunks between the upper and lower wing ballast tanks are fitted independently and it is not unusual to find leaks in the welded connections during tank testing due to sub-standard welding, a result of the welder working in a cramped space (*see* Fig. 9).

(8) Recently, a great deal of concern has arisen from inefficient welding in way of longitudinal butt welds, at ship join-ups. In one case nearly 50 per cent of the upper deck slab longitudinal welded butts, in the midship half length, were required to be cut out and rewelded. This was due to lack of root fusion and heavy slag inclusion. In another case built sections of a type shown in Fig. 10, resulted in extensive repairs after only a short period in service, the cause being attributed to lack of full penetration at the heel of the angle on the longitudinal butt weld. The weld preparation for unusual sections or heavy bulb longitudinals should be approved to ensure that full pentration is achieved. Radiographic, or other non-destructive tests should be carried out during construction.

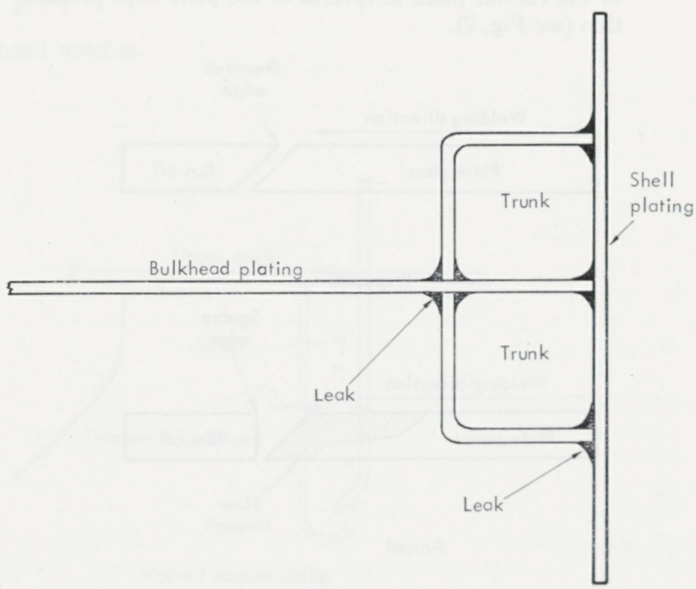


FIG. 9

Wing tank connecting trunks.

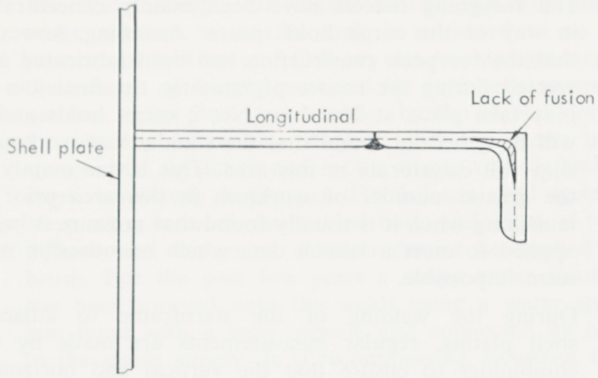


Fig. 10

Butt welds of longitudinal members.

(9) If the bottom brackets on the side shell frames and webs are erected together with the shell side panels, adjustment may be required before the brackets will fit the sloping side of the lower hopper tank. This is especialy prevalent at the forward and after holds clear of the parallel middle body. It is also necessary to ensure that the toes of these brackets are supported where they do not extend to a longitudinal (*see* Fig. 11).

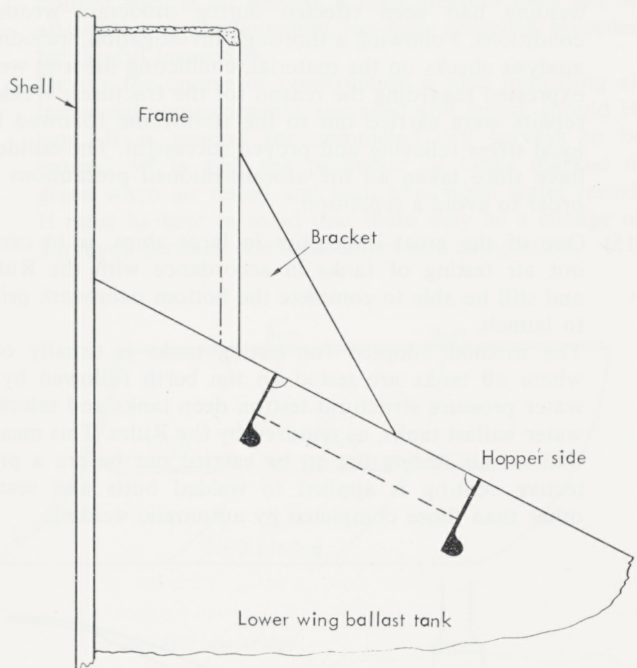


Fig. 11

Frame bottom bracket attachment.

(10) A great deal has been said recently about lamellar tearing in way of transverse bulkheads. Following an investigation some time ago where all welded connections at the tank top and bulkhead horizontal shelf plate were ultrasonically tested or checked with dye penetrant, it was decided by the shipbuilders concerned to take the following precautions.

(10 . 1) The bulkhead plating in way of the shelf was radiused thereby eliminating the double fillet welds in this vicinity (*see* Fig. 12).

(10 . 2) All tank top plates in way of the bulkhead bottom stool connections were ultrasonically tested. If any lamination or inclusions were observed, the plate was not used in this area. As the tank top plates were mainly of the same dimensions interchangeability was not a problem.

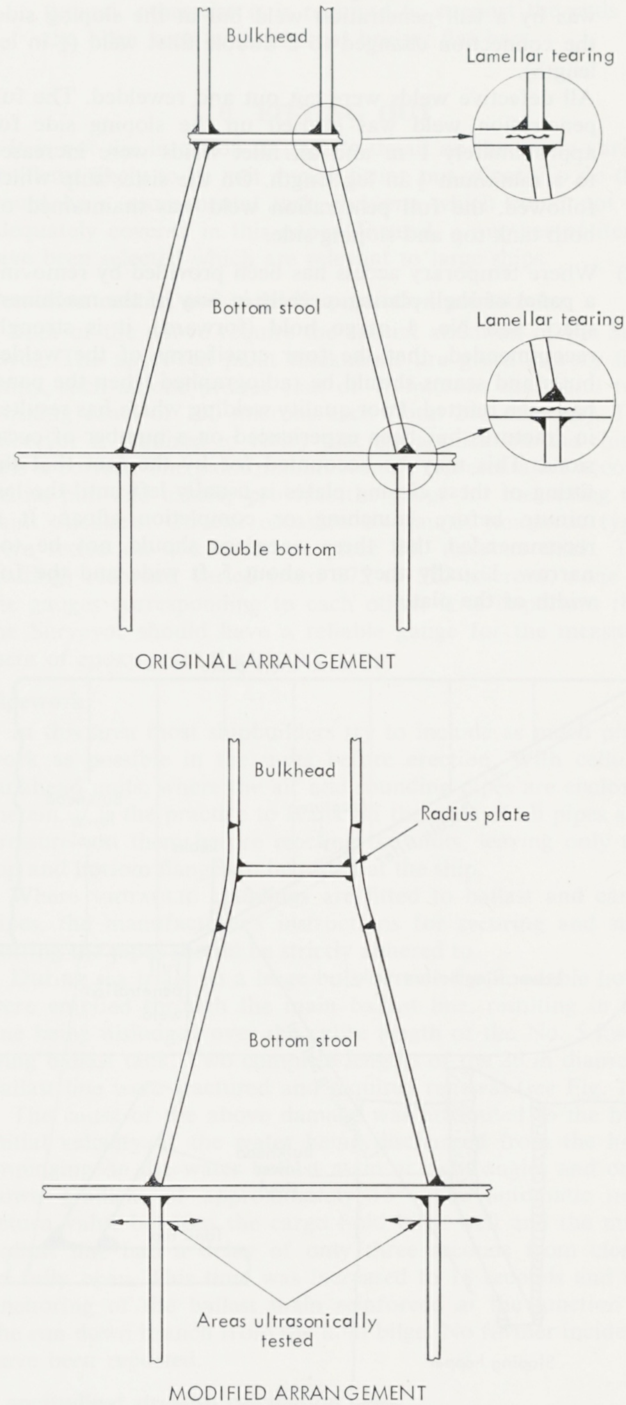


Fig. 12

Bulkhead lower stool shelf-plate.

(11) Whilst on the subject of bulkhead stools, extensive and expensive repairs were required to be effected to an O.B.O. following sea trials, when it was found, during water pressure tests of the cargo holds, that there was evidence of leaks in several of the transverse bulkhead lower stools (*see* Fig. 13). These bulkheads had been previously air tested in accordance with the Rules, without any leaks resulting. The connection to the tank top was by a full penetration weld but at the sloping side, the connection changed to a double fillet weld ($\frac{3}{8}$ in leg length).
All defective welds were cut out and rewelded. The full penetration weld was carried up the sloping side for approximately 1 m and all fillet welds were increased to a minimum $\frac{1}{2}$ in leg length. On the sister ship which followed, the full penetration weld was maintained on both tank top and sloping side.

(12) Where temporary access has been provided by removing a panel of shell plating, usually in way of the machinery space and No. 1 cargo hold (forward), it is strongly recommended, that the four cruciforms of the welded butts and seams should be radiographed when the panel has been refitted. Poor quality welding which has resulted in fractures has been experienced on a number of occasions. This may be accounted for by the fact that the fitting of these closing plates is usually left until the last minute before launching or completion afloat. It is recommended that these openings should not be too narrow. Usually they are about 5 ft wide and the full width of the plate.

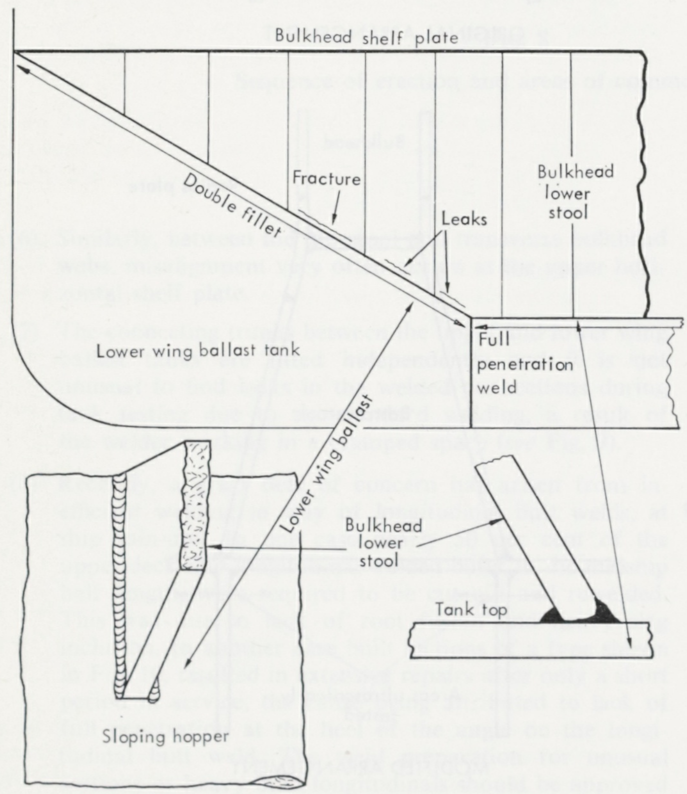


FIG. 13

Bulkhead lower stool bottom weld connection.

(13) The foregoing defects have been mainly concentrated in way of the cargo hold spaces. Assuming, however, that the forepeak construction had been fabricated and erected during the course of building, the final join-up may take place at No. 1 or No. 2 cargo holds and it will be generally found that the standard of workmanship will deteriorate in this area. This is due mainly to the greater number of workmen in this area prior to launching when it is usually found that pressure is being applied to meet a launch date which on occasion may seem impossible.

(14) During the welding of the sternframe to adjacent shell plating, regular measurements are made by the shipbuilder to ensure that the vertical and horizontal position of the centre of the boss is not displaced to any great degree. If the sternframe is a casting, preheating and low hydrogen electrodes are generally used and post heating or asbestos covers are applied to allow for slow cooling. If the welding is carried out at an exposed berth protective screens are also provided
Approximately two weeks before launching an oil tanker, a fracture of about nine inches in length appeared on the lower part of the sternframe. On further investigation 31 small fractures were found as shown in Fig. 14. None of the precautions mentioned were taken as the welding had been effected during moderate weather conditions. Following a thorough investigation, including analysis checks on the material, conflicting theories were expressed regarding the reason for the fractures. Welded repairs were carried out to the sternframe followed by local stress relieving and proved successful. The builders have since taken all the aforementioned precautions in order to avoid a repetition.

(15) One of the great difficulties in large ships, is to carry out air testing of tanks in accordance with the Rules and still be able to complete the bottom paintwork prior to launch.
The method adopted for testing tanks is usually one where all tanks are tested on the berth followed by a water pressure structural test on deep tanks and selected water ballast tanks, as required by the Rules. This means that all air testing has to be carried out before a protective coating is applied to welded butts and seams other than those completed by automatic welding.

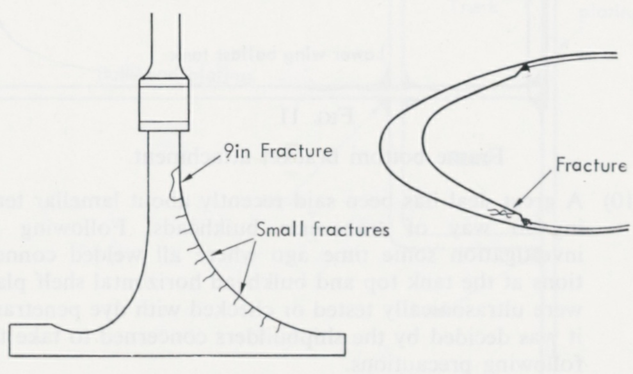


FIG. 14

Sternframe fractures.

The Rules accept leak testing carried out with soapy water solution whilst the tank is subjected to an air pressure of 0,14 kg/cm^2 (2 lb/sq in). As ships get larger, the amount of staging provided for tank tests seems to get less, either due to economies by the shipbuilder or the urgency to remove staging from the cargo hold spaces. SKY CLIMBERS and motor trucks with extending arms, commonly known as 'Daleks' are used instead. Very often to reach the welded butts and seams is very difficult and the soapy solution cannot be applied by brush. For the past few years a soapy water solution has been sprayed onto the welds using a water spray gun fitted with a soap capsule and connected by hose to the mains supply. It is recommended, however, that the distance the water may be sprayed from should not exceed 10 ft. The Surveyor's eyesight and the intensity of light in the compartment need also to be taken into consideration. All hand welding in way of W.T. bulkhead collars is always tested by the soapy solution being brushed on.

It is recommended in the Rules that pump rooms should be flood tested prior to the launch. As a great deal of equipment is fitted at an early stage, including electrically operated pumps, etc., it has been found that the builders have been very reluctant to comply. Where the bottom shell is all welded, a high pressure hose test on all welds, prior to launching has been accepted, preceded by careful inspection.

During the course of construction a plan indicating all tanks and compartments, surveyed and tested, should be kept. It is general for completed dry surveys to be crossed off in red, the perimeter of tanks marked in green when air tested and with blue when water tested. It must be kept in mind that there may be a change of Surveyor between commencement and completion.

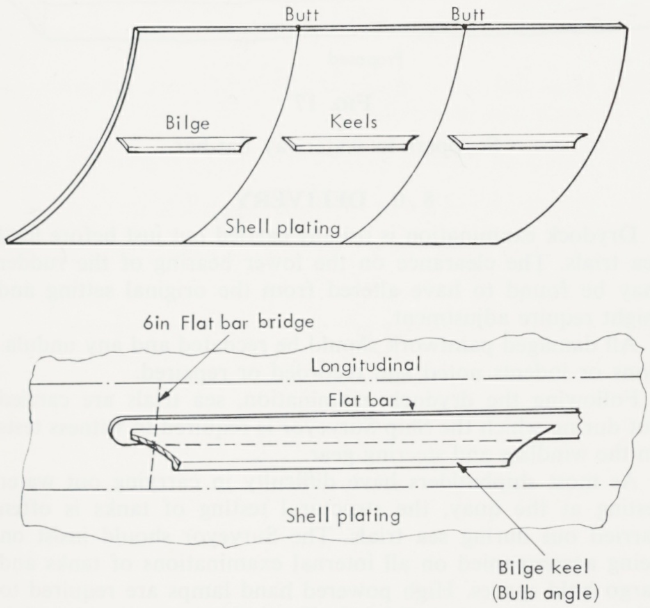


FIG. 15

Bilge keel arrangement.

(16) Bilge keels have always presented problems in unit construction and may require to be cropped and removed or left loose. Notch effects in this area are always a danger as is the possibility of locked-in stresses. Shipbuilders now appear to favour a system of intermittent bilge keels which are erected complete with each unit (*see* Fig. 15).
The bilge keels may be backed-up by an internal longitudinal, otherwise it is required to support the ends of the bilge keels with internal bridge, flat bars.

7.0 FITTING OUT

It is not the intention to go into detail on the many varied problems likely to be met during fitting out afloat. To do this would be a monumental task and one which could not be adequately covered in this paper. Instead, a number of items have been selected which are relevant to large ships.

Corrosion control and cathodic protection paintwork

Both of the above require the special attention of the Surveyor. The approved paint thicknesses are given in very fine limits, such as one primer coat of 40 microns thick and two finishing coats of 100 microns each (total 240 microns). The Surveyor is required to verify that the application and thickness is correct. The paint manufacturer's representative accompanies him and usually provides the gauge for measuring the paint thickness. On one occasion six gauges (magnetic type) were tested on a known test piece 200 microns thick. The readings recorded varied from 175 to 525 microns, none of the gauges corresponding to each other. It is important that the Surveyor should have a reliable gauge for the measurement of epoxy paint thickness.

Pipework

In this area most shipbuilders try to include as much pipework as possible in the units before erection. With cellular bulkhead units, where the air and sounding pipes are enclosed therein, it is the practice to blank off the ends of all pipes and pressure test them before erecting the units, leaving only the top and bottom flanges to be tested at the ship.

Where VICTAULIC couplings are fitted to ballast and cargo pipes, the manufacturer's instructions for securing and supporting the pipes should be strictly adhered to.

During sea trials on a large bulk carrier the floodable holds were emptied through the main ballast line, resulting in the line being dislodged over the entire length of the No. 5 lower wing ballast tank. Two complete lengths of the 26 in diameter ballast line were fractured and required renewal (*see* Fig. 16).

The cause of the above damage was attributed to the high initial velocity of the water being discharged from the hold impinging on the water ballast main at right angles and on a down gradient of approximately 15°. The automatic non-return valve between the cargo hold bilge well and the main ballast line had a delay of only three seconds from closed to fully open. This time was increased to 18 seconds and the anchoring of the ballast main reinforced at the junction of the run-down branch from the hold bilge. No further incidents have been reported.

Longitudinal strength calculation

The shipbuilder is responsible for submitting particulars of loading for homogeneous and, if applicable, non-homogeneous loads also part loaded conditions and ballast conditions in

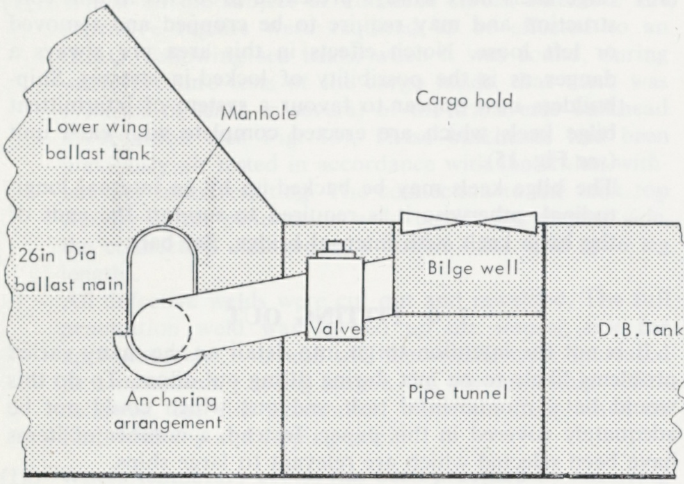


FIG. 16

Ballast line anchoring arrangement.

departure and arrival. It is most important that all conditions of loading should be fully investigated as early as possible. On checking a special loading condition, which had been overlooked during the initial calculation, it was found that a very high shear stress occurred in certain regions and intermediate frames were required to be fitted in way of the after holds when a bulk carrier was very nearly completed.

Depth moulded

Care should be taken to measure the depth moulded parallel to the side framing and not plumbed from the deck. With a ship depth of 30 m and a building berth declivity of 5 cm per 1 m a discrepancy of 6 cm could arise.

In ships with a radiused stringer/sheerstrake, when the moulded depth has been verified on the berth, it is advisable to mark a reference level on the side shell where the loadline marks may be measured from at a later stage. (This mark should be clear of higher tensile steel if cut-in.)

Accesses and escapes

Nothing appears to be laid-down regarding the minimum size of crew escapes. Very often the small trunks are fouled by rows of pipes, leaving a minimum of space to climb the ladderway. Adequate free passage is essential from the machinery space, duct keels or pipe tunnels.

Cargo hatch steel covers

Special attention is necessary with the closing arrangements and testing of steel cargo hatch covers, especially the type where cross-joint locking cleats are replaced by a side wedge closing arrangement. It is important to see that the side wedges are a bearing fit, to ensure proper closing of the rubber seal, on the cross joint.

Considerable trouble was met on an O.B.O. on the berth where the hatch covers were subjected to an air test of 0,14 kg/cm^2 (2 lb/in^2) with soapy water solution. This was followed by a pressure test at sea by filling the holds with water up to the level of the ventilator coamings on the cover tops (at the owner's request). It was only after adjustment to the position of the side wedges that watertightness was achieved.

Fittings on radiused sheerstrake

The radiused sheerstrake plate, being generally of grade E.H. material, should be free from welded attachments. Where specially approved, bollards, fairleads and accommodation ladder platforms, may be welded directly to the radius, providing they have well tapered brackets and the welding is carefully executed. Square endings on waterway flat bar scupper openings should be avoided (*see* Fig. 17).

Minor bulkheads in accommodation spaces

It is not unusual to find local buckling occurring in minor swedge bulkheads at the upper deck level, forward of the engine room casing. The extent of deformation usually increases as the upper tiers of the deckhouse are erected. Additional stiffening may be required as well as fairing.

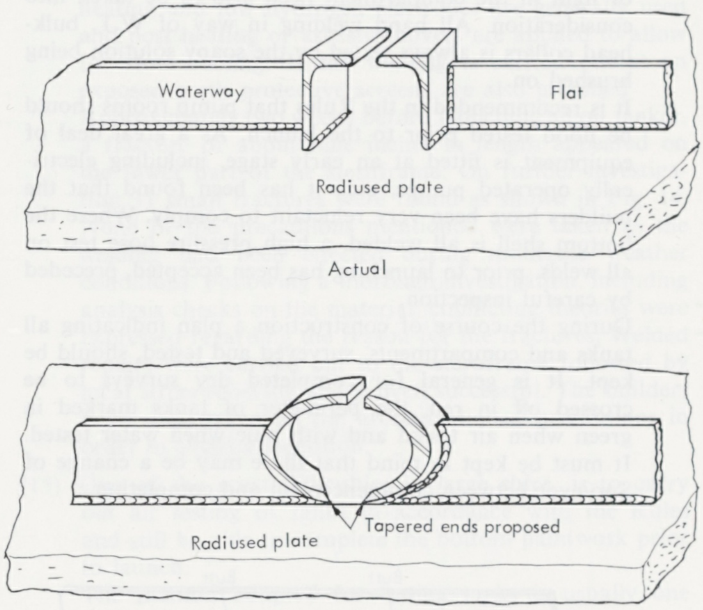


FIG. 17

Scuppers in waterway flat-bar.

8.0 DELIVERY

Drydock examination is usually carried out just before final sea trials. The clearance on the lower bearing of the rudder may be found to have altered from the original setting and might require adjustment.

All damaged paintwork should be recoated and any undulations or indents noted and recorded or repaired.

Following the drydock examination, sea trials are carried out during which the Ship Surveyor is required to witness tests on the windlass and steering gear.

As most shipbuilders have difficulty in carrying out water testing at the quay, the structural testing of tanks is often carried out during sea trials. The Surveyor should insist on being accompanied on all internal examinations of tanks and cargo hold spaces. High powered hand lamps are required to illuminate the tank bulkheads. It is also recommended that when carrying out structural tests at sea, the ship should either be stationary or going very slowly ahead into the wind and tide, to reduce the motion.

If vibration tests are carried out by the shipbuilder, the Surveyor should be informed of the results and any proposals to counteract excessive vibration. It is always good practice for the Surveyor to carry out a general tour of the ship and record any areas where vibration may be evident, the places most vulnerable being the extremities of the fly bridge, on the forward bulkhead of the engine casing, on the main deck at the stern, the steering gear flat, the engine room generator flats and fresh water and settling tank bulkheads in the machinery space.

9.0 CONCLUSIONS

In the foregoing notes any reference to Loadline, Safety and Tonnage statutory requirements was deliberately avoided, as they have all been very well illustrated in previous Technical Association Papers; nor was it the intention to detail the thousand and one defects which have to be dealt with daily and usually referred to as 'minor defects'. Surveyors are well aware, however, that a large number of major failures probably resulted from a 'minor defect'.

It was with the interest of the younger members and new entrants to the Society in mind, as stated in the introduction, that this paper was prepared. If it has proved of interest or benefited other members of the staff its purpose will have been well served. In conclusion, it is hoped that other Surveyors will be able to provide additional experiences in the discussion.

ACKNOWLEDGEMENT

But for the influence of Mr. O. M. Clemmetsen this paper would probably never have been written and thanks are expressed for his encouragement and guidance.

BIBLIOGRAPHY

(1) *Instructions to Surveyors,* Part 8, 1971. Welding of Ships.

(2) *Institution of Engineers and Shipbuilders, Scotland.* Welded Ship Construction by H. R. Gibbs and G. M. Boyd.

(3) *Lloyd's Register Technical Association* Paper No. 4, Session 1969–70. 1966 Load Line Convention: Its Implications and Interpretations by T. A. Simpson, J. M. Bates and L. Beckwith.

(4) *Lloyd's Register Technical Association* Paper No. 7, Session 1970–71. The Survey of Safety Equipment on Cargo Ships by G. Smart.

(5) *Lloyd's Register Technical Association* Paper No. 2, Session 1958–59. Tonnage by R. Gray and L. Beckwith.

(6) Final Act of International Conference on Tonnage Measurement of Ships, 1969.

APPENDIX 1

Sequence of Operation

The following list has been found to be a useful guide to the Author when carrying out new construction surveys for both Classification and Specification Services. The list covers a number of items which are only required to be examined if the Society is also to issue statutory certificates.

(1) Material to be examined during shot blasting and paint priming.

(2) 'Erection Sequence' plan to be used as progress chart for
  (a) Line assembly.
  (b) Units completed.
  (c) Units erected.

(3) A second plan showing progress of surveys and tank tests should also be kept up-to-date.

(4) Unit inspection to be carried out. (Simultaneously with owner's inspection.)

(5) Independent scantling checks to be made.

(6) Working drawings should be examined at an early stage.

(7) Dry survey examinations, tank tests and pipework tests to be witnessed by Surveyor (simultaneously with owner's surveyor).

(8) All surveys and tests to be signed for on completion. A full list of defects dealt with should be retained for reference.

(9) Close co-operation should be maintained with shipyard quality control team and owners' representatives.

(10) Shipyard approved standard practices and tolerances to be confirmed and complied with at all stages of fabrication and erection.

(11) Keel sights and bottom structure should be checked for fairness regularly.

(12) Any modifications due to faulty workmanship, wrong material sizes or human error, should be brought to Surveyor's notice by shipbuilder.

(13) The use of tee-pieces, small panels and backing strips are to be kept to an absolute minimum. In way of main structural members, repairs are to be agreed to by Surveyor, prior to being effected.

(14) Welding of temporary attachments to higher tensile and special quality steel to be avoided wherever possible. Otherwise welding is to be executed with the same care as for permanent members.

(15) The removal of temporary attachments is to be carefully carried out. Scars resulting from careless removal of same are to be welded with suitable electrodes and dressed smooth.

(16) Any steel material defaced as a result of hammering and heating is not to be accepted.

(17) Bridges and lugs used for lifting and fairing are to be kept to a minimum.

(18) Welding is to be carried out with a minimum of restraint.

(19) Hand burning is to be kept to a minimum. All ragged edges on main structural members are to be dressed smooth.

(20) A sequence of welding for main structure is to be approved and complied with wherever possible.

(21) Regular radiograph examinations should be carried out, preferably at a specific time each week.

(22) Application of paint, number of coats, drying out period between coats and thickness spot checks to be carefully observed.

(23) Fire hydrants to be tested with hoses coupled using
  (a) Emergency fire pump, and
  (b) ballast pump.

(24) Examine and check life saving equipment.

(25) Examine and check all lifeboat equipment. (Deck officer also to sign on approval.)

(26) Sailing and rowing test to be held on rowing boats.

(27) Tests of disengaging gear of davits, with boats loaded.

(28) Individual tests of davit arms (i.e. before installation on board) to be verified.

(29) Test launching of buoyant apparatus (drop test in water).

(30) Boat lowering tests—to be lowered fully loaded with weights, into water, unloaded and boats raised. Operation of boat winches to check.

(31) Deck control gear for all tank valves, operation to check.

(32) Hose test hatch covers, shell W.T. doors, skylights, side lights and windows.

(33) Check all freeboard items (closing appliances).

(34) Check all freeboard sidelight deadlights (in position).

(35) Mooring cables to be checked to comply with the Rule requirements.

(36) Lifelines and walkways to be rigged and examined.

(37) All fresh water tanks to be checked for cleanliness before coating, and on completion.

(38) All tanks to be checked for cleanliness before closing.

(39) All holds, 'tween decks, steelwork to be finally examined.

(40) Chain locker to be examined before painting and on completion.

(41) Chain cables to be ranged, and joining shackles correctly marked, also attachment of ends in chain locker to be examined before stowage continued; connection of anchors to be examined before stowage.

(42) Final docking—any deflections during construction to be rectified as necessary, or noted (at owners' option). Rudder to be tested from hard-over to hard-over without mechanical aid. Pintle clearances to be checked. Helm indicator movement to be witnessed.

(43) Freeboard and draught marks to be checked.

(44) Accommodation ladders to be rigged and lifting equipment tested. Ladder to be loaded, in lowered position, with the equivalent of one man per step.

(45) Deck awnings to be examined, rigged.

(46) Wash deck services to be examined.

(47) Ship's whistle to be tested.

(48) All deck lighting to be verified.

(49) Bilges to be finally examined for cleanliness and tested.

(50) Cargo handling tests to be witnessed (when necessary).

(51) Stability tests—condition of ship to be checked before inclining.

(52) Main hatch beam identification marks to be verified, i.e. net tonnage and official number.

(53) Vessel's draught in light condition to be checked and recorded when final deflections of main engine crankshafts are taken.

(54) Check that the services (e.g. salt water, fresh water, hot and cold) to all cabins, public rooms, toilets, etc., function efficiently.

(55) Piping systems to be examined for efficient clipping, insulation, etc., before fitting deck head panels in alleyways.

(56) Pressure test the various services (i.e. with a certain number of valves or taps open on each deck-level note the pressure drop).

(57) Check that each space has an identification tab and that these correspond with plan in chartroom.

(58) Anchors to be lowered to verify the clearance of bulbous bow, prior to sea trials.

(59) Examination of all cargo or ballast control equipment under working conditions.

(60) Check on all items of fire-fighting equipment (as per approved plan).

(61) Check the efficient closing of all fire-proof doors.

(62) Check the CO_2 installation (with manufacturer's representative). Compressed air of sufficient pressure to operate alarms to be used. Sprayers and nozzles to be checked that they are clear.

(63) Tests on telegraphs, telephones and speaking tubes.

(64) Test loud speaker relay system.

(65) All navigation aids to be tested. Makers' representative to demonstrate that all are functioning correctly.

(66) Test stewards call-bell system.

(67) Test the operation of all vent flaps and engine room skylights.

(68) During sea trials an examination of all spaces (in particular passenger accommodation and public rooms) with particular attention being paid to vibration. Hull vibration amplitudes to be observed and noted.

(69) Check the operation and installation of lifts. Safety devices for passenger lift.

(70) Check the efficient filling and emptying of swimming pools.

APPENDIX 2

List of Certificates

The following is a list of certificates and reports which are normally required to be dealt with during the construction of a bulk carrier.

NUMBER	CERTIFICATE OR REPORT	ACTION
1	Request of Survey	Completed by the shipbuilder and forwarded to Headquarters.
2	Launching Return	To be forwarded to Headquarters within seven days after launch.
3	Builder's Stage Reports	If authorised by Headquarters, certificates may be issued to shipbuilders.
4	Freeboard Computation (C11 Calc.)	To be forwarded to Headquarters.
5	Freeboard Report (C.11 (C.11.R)	To be forwarded to Headquarters approximately five weeks before handing over.
6	Freeboard Assignment	Received from Headquarters.
7	Freeboard Verification	To be forwarded to Headquarters about two weeks before handing over.
8	International Loadline Certificate (+1 copy)	Received from Headquarters for issue on completion to shipbuilder.
*9	Safety Equipment Report (S.E.1)	To be forwarded to Headquarters about five weeks before handing over.
10	Interim Certificate of Classification (Certificate B)	Issued by Surveyor to shipbuilder on completion.
11	Safety Construction Certificate	Witnessed by an independent Surveyor (usually Surveyor in charge at Port) and issued to shipbuilder
12	Freeboard Declaration Rpt. C.11 (Dec.)	To be forwarded to Headquarters within 24 hours of handing over.
13	Partial Declaration	If a U.K. registered ship, to be received from D.T.I. and forwarded with F.E. Rpt. to Headquarters.
*14	Cargo Ship Safety Equipment Certificate.	Received from Headquarters for issue on completion.
*15	Tonnage Formula Certificates T1 and T2	To be forwarded to Headquarters as early as possible.
*16	Tonnage Certificate	On receipt from Headquarters to be witnessed by owner, master or agent and Surveyor before being issued to shipbuilder.
17	Stability Particulars and Loading Conditions	To be forwarded to Headquarters as early as possible, on completion of the inclining experiment.
18	Crew Accommodation Certificate	A Report 10 which is completed by the Surveyor and issued to shipbuilder.
19	Safety Construction Declaration	Completed by Surveyor and forwarded to Headquarters with F.E. Rpt.
20	First Entry Report	Forwarded to Headquarters as soon after handing over as is possible.
21	Classification Certificate	Received from Headquarters. Particulars to be verified before issuing to shipbuilder.

* Only required to be dealt with if the Society is required to carry out statutory surveys.

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12	Freeboard Declaration Rpt. C11 (Dec.)	To be forwarded to Headquarters within 24 hours of handing over.
13	Radio Declaration	If a U.K. registered ship, to be received from D.T.I. and forwarded with F.E. Rpt. to Headquarters.
*14	Cargo Ship Safety Equipment Certificate	Received from Headquarters for issue on completion.
*15	Tonnage Formula Certificates T1 and T2	To be forwarded to Headquarters as early as possible.
*16	Tonnage Certificate	On receipt from Headquarters to be witnessed by owner, master or agent and Surveyor before being issued to shipbuilder.
17	Stability Particulars and Loading Conditions	To be forwarded to Headquarters as early as possible, on completion of the inclining experiment.
18	Crew Accommodation Certificate	A Report 30 which is completed by the Surveyor and issued to shipbuilder.
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Lloyd's Register Technical Association

Discussion

on

G. S. McIntosh's Paper

SURVEYING O.B.O's AND LARGE BULK CARRIERS

Paper No. 2. Session 1974-75

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Hon. Sec. A. Wardle
71, Fenchurch Street, London, EC3M 4BS

Discussion on Mr. G. S. McIntosh's Paper

SURVEYING O.B.O's AND LARGE BULK CARRIERS

Mr. F. N. BOYLAN

I think it would be true to say that the majority of papers read to the Technical Association are by colleagues from one or other of the departments in Head Office, or one of the central approval offices throughout the Society. They are usually by specialists in a certain subject or from a specific department of the Society's work and aimed at allowing others to see something of the work in that department and to gain some knowledge which they would not otherwise acquire unless they actually worked there.

It is refreshing, therefore, to read this paper by Mr. McIntosh who has valiantly tackled a much wider and more general topic, the work of a Surveyor responsible for the inspection during construction of large ships. Mr. McIntosh has referred specifically to O.B.O.'s and large bulk carriers, but what he has to say is valid for most other large ships and I consider that he has made a good job of this very difficult task.

In his introductory remarks Mr. McIntosh indicated that he feels somewhat uncertain of the future of Lloyd's Register because of the present Government's proposal to nationalise shipbuilding. It might be of interest if I say that I have worked for over 20 years in a country in which all the largest and most important shipyards were actually nationalised and that I found no difficulty or difference in working under those circumstances and working in this country. Provided shipyards are well organised and efficient, the identity of the owners has little or no bearing upon the work of the Society. They still have to build ships and they still have to class them to suit their clients' (owners') requirements and we, as a classification society, just proceed in the normal way. Lloyd's Register is, of course, international in its functions so that, in my own estimation, whether the yards are nationalised or not, we need not worry.

Another of Mr. McIntosh's observations is that a completely different type of recruit is required nowadays to deal with the very complex nature of the work at the present time. I would say that the only difference is that we require a more highly trained and more specifically qualified recruit than formerly. Mr. McIntosh was referring to the training of new recruits and suggested that we must expect to spend several years in training each one or be faced with the possibility of theoretically competent, but practically inexperienced Surveyors being placed in charge of important work for Lloyd's Register.

I admit there exists a tendency to take younger men (we have some as young as 23) but usually these are men who have a very high standard of qualification (we have several Ph.D.'s and many M.Sc.'s for example) for some specialist types of work but, in general, the Society still requires adequately qualified men who have also had satisfactory practical experience and have proved themselves of certain abilities within the industry. Hence, not everyone joining Lloyd's Register requires the same degree of training. However, we now have a training manager in this country, Mr. McCulloch, and a training centre, and there are a series of truly excellent courses prepared for training recuits in areas in which they might be weak. There is a scheme for drawing Surveyors from all over the world to London for these special courses and another training centre in the Orient deals with Japanese speaking staff. I can assure you the matter of training is very much in the forefront and in the thoughts of technical management and, I believe, is being taken care of as adequately as possible in existing circumstances.

Training courses have two objects; one is to instruct men in a subject of which they might be ignorant, and the other is to bring technical staff scattered across the world up-to-date with the latest developments within the Society, so the question of training is not restricted merely to training raw recruits. Every effort is made to spread the benefits of the training programme as widely as possible throughout the staff.

In his paper, Mr. McIntosh has avoided the temptation to go into great detail. Many years ago a paper was written by a colleague from a port in the U.K. on the subject of "Special Surveys of Old Cargo Ships". One sub-heading was 'Items which should be specially carefully examined for corrosion and/or fractures'. There followed a detailed list of every conceivable part of the structure and fittings from rivet heads in the reverse angles on double bottom floors to bottle screws in the rigging!

Mr. McIntosh on the other hand, has managed to compile quite a concise document of what really amounts to a series of hints and general guidance which will surely be of great help to less experienced colleagues.

I find the two appendices most useful, if rather startling. Appendix 1 is frankly somewhat terrifying. Appendix 2 is illuminating in the number of certificates which must be supplied in most cases. If any younger colleague should comply with all these items I am quite sure that he will run into no serious difficulty with H.Q. However, in fairness to a junior Surveyor reading such a document for the first time, and suffering from shock as a result, I think it only correct to suggest that Mr. McIntosh has not merely indicated the ideal performance, he has also combined the work of classification and owner's specification without clearly distinguishing one from the other. This combination is not clearly indicated in the paper itself, except that in Appendix 1 he does state that the list covers surveys for both classification and specification services.

This is not a criticism. It will be of great use to Surveyors who have to tackle both kinds of work but I would suggest that no one individual could possibly carry out efficiently all the work shown in this paper. On the subject of preparation, for example, Mr. McIntosh says, 'It has been found that a great deal of trouble can be avoided if all material is carefully examined for latent laminations and surface defects after shot blasting'. Plating should be examined after shot blasting; but it is completely beyond the capacity of a busy Surveyor to do this to any great extent. (I can remember a case in which the owners of a ship for very special purposes required surface inspection of all plates after shot blasting, both for the hull in the midship half length and for the independent tanks. We had to make a separate contract for this to be done and one Surveyor and an assistant were occupied full-time over quite a long period in doing it.) It must be remembered, of course, that plates have two sides and surface inspection

can involve turning them over, so, provided a Surveyor does a general sort of check, from time to time, to ensure that inspection is carried out, he will be exonerated from having to tackle it himself.

In Appendix 1, among the 70 items listed for attention, one is struck by Item No. 66 'Test stewards' call-bell system'. One can think of a very practical use to which this test could be applied by some of our more seasoned colleagues; during trials at sea, for example.

There are several other points which come under the same category, i.e. that a normal classification Surveyor could not reasonably be expected to do on his own. In fact, Mr. McIntosh puts his finger on the real problem in his remarks on inspection and quality control.

I refer to the necessity for good quality control by the shipyard themselves. I think everyone will be familiar with the latest developments which are taking place in this line and the scheme for quality assurance which was started in Japan and is now being developed in Head Office by Mr. Phillip, and in which great interest is being shown by some Continental builders.

I had hoped Mr. Phillip would be able to give us the benefit of some remarks on this subject presently. Unfortunately, he cannot be present but perhaps he could give us a talk on this subject to tell us the present state of the art on another occasion.

In essence, quality assurance includes a recognition that in the very large ships which are being built nowadays and with the present-day speed and efficiency of prefabricated welded construction, it is a physical impossibility for a Surveyor to see everything that is going on and he should in fact become almost an integral unit of the shipyard's own quality control scheme. As Mr. McIntosh says, quite rightly, the control of quality and dimensions should not be under the production manager of the shipyard. There should be a separate department, with a channel of communication with senior management and the Surveyor should co-operate very closely with this team. His function really becomes one of ensuring that the quality assurance team are functioning efficiently.

There is a tendency in this country to adhere to more traditional methods of control and to throw the weight of all inspection heavily on the shoulders of the classification Surveyors. In such yards Surveyors are at a disadvantage but this is not a truly efficient system and I feel confident that the quality assurance scheme which has been started will now become the accepted method of inspection in all large shipyards.

Item 8 in Appendix 1 could only be applied in such a scheme, especially the full list of defects which is referred to there.

It is undesirable, in my view, to increase the volume of Surveyors' paper work (which becomes ever greater and which tends to sink the Surveyor in office duties rather than inspection) but if the shipyard's own team can be induced to keep proper records of faults, this will enable the incidence of defects to be watched very closely.

In Section 7, Mr. McIntosh says, 'It is most important that all conditions of loading should be fully investigated as early as possible', etc. These are, of course, design problems and these will be investigated before the scantlings of the ship are fixed and should not worry our colleague in the outport.

Mr. McIntosh refers to checking the windlass. It is normal, of course, to witness both anchors being lifted, usually at the same time but at no particular speed. I would like to know whether he considers this is a suitable test, or whether he normally applies any other test to windlasses during trial periods.

Some of the detailed sketches, Figs. 4 and 5 for example, show rather ideal conditions for the fitting of collars. Perhaps Mr. Marsden would make a comment or two on this question because it can be of great importance in eliminating causes of fractures in plating.

On such a paper one could continue to talk for a long time but perhaps I should restrict my comments to just one other point.

Item 8 in Section 6.1—lack of root fusion and inefficient welding in butts of side and deck longitudinals. The case to which Mr. McIntosh refers caused a great deal of trouble for all concerned and the real cause, in my view, was that a certain amount of 'green' material had been left on each logitudinal and, in fact, also on the plate length of each prefabricated unit before lifting into the ship, so that each longitudinal had to be burned off to ensure a correct alignment and fitting. In burning off the longitudinals, the end weld preparations were also removed and an attempt was made to weld butts of longitudinals with no edge preparation on one side of each butt. This is a case in which no opportunity was afforded to the Surveyors to examine the connecting butts between fabricated units on the stocks before welding was commenced. Such an occurrence should not happen in any yard in which a reasonable quality assurance scheme is in operation.

Mr. Phillip, when I approached him on the matter of quality assurance, asked me to raise a question for him relating to this paper. It was as follows:—

> "In the sequence of operation no mention is made of the construction and alignment of sternframes and rudders. It is understood that some shipbuilders order pre-aligned sternframes incorporating rudder axles complete with finished coupling bolts and finished coupling bolt holes. If this is the case, I would be pleased to know what arrangements are made by the builders to construct the sternframe and 'hold' the alignment during the welding operations. If difficulties are found and malalignment results what methods of repairs are carried out?"

It is quite true, as Mr. McIntosh remarks, that there is a wealth of information on hand in the Society's records and that this should be put to the best possible use within the Society, it being noted that outside bodies frequently apply to Lloyd's Register for information which they could not hope to get anywhere else. The Society has, of course, two departments, Statistics and Technical Records, which handle such enquiries and compile information which forms the basis of this service. Surveyors everywhere are, therefore, earnestly requested to feed back to Head Office all interesting facts and records of any kind relating to the work which they do. These facts need not always be included in Committee Reports but this does not mean that they should be overlooked. I would draw attention specially to the Noteworthy Defects List. We have had to abandon the publication of "Hull" items in recent issues because of a crisis in manpower precipitated by a colleague who died suddenly in London Office, but it is vitally important to Technical Records' office that Surveyors wherever they are stationed should continue to report items of structural failure or weakness or undesirable details of construction which might cause trouble, or special features arising from damage of whatever cause, etc. By this means trouble can often be avoided, or, if it should occur, prompt and most desirable action may be taken and the same sort of trouble

avoided on sister ships, or ships of similar type. It is essential, therefore, the Noteworthy Defects List be studied with attention and that co-operation be extended to Head Office as far as possible in feeding back information which might be of interest and which might well be the basis of amendments in the Society's Rules and practices.

It only remains for me to congratulate Mr. McIntosh on a most useful and topical paper. I am sure that there will be a lively discussion to follow.

Mr. J. G. BEAUMONT

First, may I add my congratulations to Mr. McIntosh for preparing a paper which will be of great service to the younger Surveyor and of much interest to many of the older ones. In papers of this kind one is always conscious that much detail has had to be omitted on account of restricted space. As a result discussion tends to fill in some of that detail as well as extend and add to the main themes. Most of my comments will be confined to these main themes. Moreover, they will be confined to classification rather than to specification matters.

Mr. McIntosh states that the Surveyor should examine working drawings at an early stage and I would heartily endorse that. I feel that there is no better place to do this than in the Drawing Office, where a few minutes spent each day can be the most profitable in a Surveyor's day. It is essential that the Surveyor develops a 'nose' for potential trouble spots in detail design which are not always forseeable from the basic approved plans. This is a sure way of preventing production hold-ups later. Even to amend a working plan after it is drawn is to cause a problem since the plan itself is a link in the production schedule.

In this paper we are talking of large ships, and the essential difference in surveying the prefabrication and erection of such ships is the effect of the relative increase in the size of internal primary and secondary members with respect to shell panel size. This leads to a predominance of such internal structure in each prefabricated unit. This, in turn, has required of the builder a greater three-dimensional accuracy in prefabrication techniques, and herein lies many of the Surveyor's potential difficulties. Mr. McIntosh has rightly drawn attention to the need for increased quality control in this area. New concepts are afoot in quality assurance methods in the most advanced yards and it is becoming increasingly apparent to the industry that sustained continuity of high speed production is only possible in association with advanced quality control techniques. It has taken some a long time to realise that such control is an aid to production rather than a constraint. The need for a universal standard of tolerances is becoming daily more apparent and I feel this should now be given high priority by the Society if the quality assurance methods mentioned by Mr. Boylan are going to be widespread. Meanwhile, as Mr. McIntosh says, it is essential that the Surveyor develops a close understanding with the builders on a mutually acceptable standard. Before leaving the topic of quality assurance schemes, with which I am in total agreement and on which I could spend considerable time, all I would say is that the Surveyor should augment the system and not be dominated by it if he is to present an independent submission to Committee on completion of construction.

With regard to defects in automatic welding it is highly desirable that these are dealt with at source. Yard inspection should be automatic and conducted as soon after such welding as possible, preferably in the sight of the welding operator. In this way the cause of the defect can be rapidly corrected by the operator to prevent a build-up of units requiring repair. Such a build-up again presents an interruption in production.

With reference to unit lifting devices, I must say that the arrangement shown in Fig. 3 appears a little frail and could lead to damage of the stiffener web, etc., for heavy units. Perhaps Mr. McIntosh could comment on this. One small point, I wonder if Mr. McIntosh could state why soap solution should be hand brushed on the welding at watertight bulkheads? I have found a solution of proper concentration from a well adjusted atomizing gun to be most efficient and far quicker than hand brushing. I would endorse Mr. McIntosh's remarks on erection tolerances and would add that I have found the junction of the hatch end beam with the transverse in way in the topside wing tank of bulk carriers to be an area of frequent misalignment.

Finally, I was pleased to note the reference in the paper to the need for the Surveyor to satisfy himself as to the accuracy of the berth blocking arrangements. I have always felt that the corrective instinct of many Surveyors is stronger than the preventive instinct, and that this leads to an unfortunate image of his role. It stands to reason that erection fit-up will only be as good as the way in which the bottom blocks are laid and maintained true as erection proceeds. For the larger VLCC's an out of plane maintained tolerance of ± 3 mm to the base plane has been found necessary to give really satisfactory results. Can Mr. McIntosh say how such a figure compares with his experience, for the ships under discussion?

I am sure that many of our colleagues will have much to add to this discussion. Mr. McIntosh deserves our thanks for his efforts in preparing and presenting his paper.

Mr. R. R. LINTELL-SMITH

I would like to compliment Mr. McIntosh on his most informative paper which I am sure will be of great value not only to new Surveyors but also to Surveyors not actively engaged in survey work, such as myself, and will enable them to keep abreast with some of the problems encountered during construction and their remedies.

In the Crawley Research Laboratory we have been involved in two major investigations associated with the failure of butt welds in longitudinals and lamellar tearing of tank top plates, section 6.1 items (8) and (10) in the paper refer. I am sorry that there has been insufficient time to prepare slides to illustrate the problems experienced.

I am sure that Mr. McIntosh is fully conversant with the metallurgical report on the failure of the butt welds in longitudinals. Although the failures were predominantly associated with lack of fusion at the position shown in Fig. 10, the quality of the weld as a whole was in question, and it appeared that in addition to insufficient weld preparation the problem of fit-up was a contributory factor. I would therefore respectfully suggest that the penultimate sentence on page 6 should perhaps read, 'The weld preparation and fit-up for unusual sections or heavy bulb longitudinals should be approved to ensure that full penetration can be achieved.'

I do not know whether any weld procedure tests were carried out on this joint, but in retrospect I think that some of the difficulties encountered could have been forseen if a procedure test had been carried out under the restricted access conditions and welding position which were present during construction.

With reference to lamellar tearing of tank top plates, sections from similar constructions to those shown in Fig. 12, and which experienced severe lamellar tearing have been examined at Crawley. Unfortunately, the remedy of replacing the cruciform joint with a longitudinal bar proved to be as ineffective as the original joint for other metallurgical reasons.

If I may briefly expand on the metallurgical features of lamellar tearing, I think it is first desirable to differentiate between fractures due to gross plate laminations and those occurring as a result of lamellar tearing. The former generally result from plate defects caused by insufficient cropping of the ingot prior to rolling. Lamellar tearing, however, is a phenomena which can occur when severe restraint is induced across the thickness of the plate during the deposition of heavy fillet welds. Plates which contain normally acceptable levels of non-metallic inclusions in both size and distribution can be affected. Tearing occurs in the heat affected zones of the welds and the tears are characterised by their 'step-like' or 'terraced' appearance which results from the shearing of ligaments between inclusions which have torn open.

Therefore I think that Mr. McIntosh would be more correct in saying in the second sentence of Section 6.1 (10.2), that, 'If any lamination, large inclusion or heavy concentration of inclusions were detected, the plate was not used in this area'.

Although ultrasonic testing and the rejection of such plates will reduce the incidence of lamellar tearing, it is not fool-proof and much depends on the level of strain imposed in the through thickness direction of the plate during welding and this should be borne in mind in the design stage and during assembly.

With regard to the radius plate introduced into the bulkhead plating it is possible that lamellar tearing could also occur in these plates, and would it not be prudent to ultrasonically test the plates as well?

If I could introduce one 'chestnut' which crops up at regular intervals in the laboratory and is similar in nature to the failure of the longitudinals, may I draw attention to the dangers associated with lack of fusion defects resulting from incomplete penetration of butt welds in rubbing bars, which are in turn fillet welded to shell plates.

Mr. J. R. G. SMITH

I am delighted that Mr. McIntosh has found the time and energy to write this paper. Production methods and the types of ships built have changed considerably in recent years and it is essential, in my view, that individual experience gained in this field be made available to all. Mr. McIntosh has contributed nobly to this end in writing and presenting this paper and I wish to thank him for his efforts. It is not easy to find the time to do this sort of thing and I hope this paper will inspire other experienced field Surveyors to follow suit.

In the introduction to his paper, Mr. McIntosh states that there would appear to be a need for an arrangement for recording defects and difficulties encountered by Surveyors during the construction of new ships. I could not agree more, and in my contribution to Mr. O. Nilsson's excellent Technical Association Paper No. 2, Session 1969–70, 'Some Notes on the Hull Survey of New Construction in Sweden', I proposed a method of doing just this. I still think this proposal is valid.

I would also like to comment on the sequence of operation given in Appendix 1 of the paper. I am sure Mr. McIntosh would agree that the items given in his list appertaining to fire protection, detection and extinction should now be superseded by the comprehensive list of 'survey and test procedures' given in Appendix I of Mr. Coggon's paper on this subject, which was presented to the Association last month.

Mr. McIntosh, of course, could not have been aware of these at the time of writing his paper. However, there are also items given in his 'sequence of operation' appertaining to the survey of crew accommodation. In this respect, I would refer him to Technical Association Paper No. 4, Session 1970–71 on this subject. It is hoped the list of tests and inspections and the survey chart given in that paper may be of some assistance. Also Mr. McIntosh's Appendix 2 gives the impression that a Crew Accommodation Certificate is required for every ship. I am sure this impression is unintentional, as the survey of crew accommodation is only carried out under the circumstances outlined in the aforementioned Technical Association paper.

Finally, I would like to thank Mr. McIntosh once again for his very interesting and stimulating paper, and for giving me the chance of a little personal 'plugging'.

Mr. B. E. PRINCE

The Author is to be congratulated on a paper which to the younger Surveyor and for the Surveyor away from field work for a long period will be very useful particularly with regard to Appendices 1 and 2. The Author's views on the following comments would be appreciated.

In view of the fact that ships are increasing in size and are continually being optimised to give minimum scantlings, detail design, correct fit-up and preparation is becoming increasingly important. Is it not therefore necessary for the young Surveyor at which this paper is primarily directed to have a fuller understanding of those parts of the ship which are subjected to high bending and shear stresses so that particular attention can be paid to these positions? Typical examples are,

(a) the effect of hold length to breadth aspect on the shear and bending stresses which occur in the double bottom structure of the ship,

(b) the high shear stresses which occur in the side shell plating in the alternate hold and non-uniform loading conditions.

(c) the stress concentrations which occur in the deck plating between and around weather deck hatches.

Obviously these examples are just the start of a very extensive subject, but basically every Surveyor should ideally begin his career in a plan approval department and develop a 'feel' for structure before undertaking field survey work.

Under the item on longitudinal strength it is stated that the shipbuilder is responsible for submitting loading conditions. However, final loading conditions are normally contained in the Trim and Stability Book and it is the responsibility of the Surveyor to forward this to Headquarters (as listed in Appendix 2). Whilst preliminary loading conditions are generally forwarded at an early stage, changes do occur in the loading conditions and the purpose of this comment is to emphasise the importance and the effect of such changes as illustrated in this paper.

In 1967 there was issued a booklet entitled 'Detail Design in Ships' which for a new Surveyor was very useful. Does the Author see a need for this booklet to be updated and re-issued?

Mr. T. Farrell

My congratulations also to Mr. McIntosh.

The Author's comment, during presentation, regarding the necessity of ensuring that over-zealous production of assemblies does not result in trouble at the erection stage due to incomplete welding, misalignment, etc., brings to mind a case within my own experience. The ship in question was produced by a reputable Clydeside yard, now defunct, and the difficulties arose as a result of an inability to match, in erection at the berth, the rate at which prefabricated assemblies were being produced. Pressure to erect the emanating stream of shell panels, bulkhead units, etc., resulted in bad fit-up and widespread misalignment.

Typical examples of the latter were: —

(a) Transverse frame space which measured 30 inches at the tank top and 32 inches at upper deck.

(b) Shell panel butts off vertical line, resulting in a 'serrated' shear strake top edge.

(c) Whole series of deck beams freed for a distance of 5 feet to 15 feet from ship side to obtain alignment with frames.

(d) Misalignment of double-plate bulkhead panels and internal webs.

(e) Bad fit-up of aft peak structure, resulting in the peak bulkhead and every floor aft being cropped or extended by inserts.

All of these defects were made good at the building berth (at considerable cost). The shipbuilders concerned were also prominent in the local repair industry and there was some speculation that this was the biggest repair job they had encountered. This surely was a case where the shipyard paid dearly for its lack of quality control.

I would, finally, like to add comments to those preceding on the subject of Fig. 10 and related remarks in paragraph 6 . 1 (8) of the paper. In the case of the ship which most notably suffered as a result of defects of this type, I believe that every butt weld in side and bulkhead longitudinals was completed at the berth, their numbers running into the thousands and some being as high as 24 metres above the base line. Although adequate non-destructive testing would have ensured timely discovery of the gross number and nature of defects which resulted, its absence was not responsible for their occurrence. Perhaps the whole practicability of building a very large ship in this manner is so defect-prone as to be questionable.

Mr. D. Gray

I hoped that the Author would allow a simple electrical engineer to make some comments on a paper devoted to problems of naval architecture. As I did not even understand some of the expressions used in the paper I hope that I will be excused if my comments are judged to be naïve.

I was both surprised and somewhat astonished at some of the items contained in the description of the Ship Surveyor's task. For example: —

(a) Section 3 . 0: 'The Surveyors should have the opportunity of examining working drawings . . .'
'It has been found that . . . if all material is carefully examined . . .'
No doubt this is all good sound advice but how much time can be devoted to these tasks? There must be a tremendous amount of 'material'; each plate has two sides; only some of the 'material' will be destined for a Lloyd's classed ship. Could the Author explain how these tasks were encompassed?

(b) Section 4 . 0, Items 1–9: The paper implies that the Ship Surveyor should see to all these items. I have doubts as to whether a Ship Surveyor could effectively carry out all these tasks in their entirety and would be grateful for some further elucidation by the Author.

(c) Section 3 . 0: 'The Surveyor should have the opportunity of examining . . . have been included in the computer tapes . . .'

In my experience programming and tape preparation are very specialised tasks. Does the Author mean that a successful Ship Surveyor must also be competent in this very specialist field?

The above queries (a), (b) and (c) are minor in themselves but in total they would seem to impinge on the middle management of the shipyard organization. Is such interference accepted willingly in 1974 with current rates of design and construction. I could well remember a comment by another naval architect (Mr. O. Nilsson, Technical Association 1969/70) when it was pointed out that with existing speeds of ship construction it was not possible for the Surveyor to carry out the same work, or do it in the same maner as he did in 'the good old days', because little interference with operations can be tolerated.

In Section 3 . 0, Item 5 caught my eye. Surely the problem outlined involves a technical decision, and the way in which paragraph 5 is phrased may perhaps imply that the responsibility for the technical decision can be transferred to the shoulders of the owner. In my view the responsibility must be accepted by the Surveyor alone.

Finally, a subject dear to my heart. In Section 8 . 0 there is a reference to vibration tests carried out by the shipbuilder and the Surveyor being informed of the test results.

Vibration is one of the marine parameters which is a 'killer' for control equipment and also electrical equipment. There have been many instances of such equipment failing in certain ships when the same equipment had a long history of successful performance in other ships. On investigation, excessive vibration was the prime cause of failure. It was this feature, among others, that led the Society to instigate type testing of such equipment against marine environment conditions, particularly vibration and temperature. The test specifications are available to all in the Society's 'List of Type Tested Equipment'.

Could the Author describe the vibration test carried out by the shipbuilder? If the results are made known to the Ship Surveyor what does he do with the result? Can the Surveyor demand a reduction in the vibration level if it were to exceed that described in the type test specification previously referred to (range 1–100 Hz; amplitude varying from 10–0·05 mm)? It is very cold comfort to the control engineer or electrical engineer, whose equipment fails to operate after say, 12 months in service, to learn that the level of vibration measured on board far exceeds that to which his equipment was type tested. I would hope that the day may come when class is refused for a ship with an unacceptably high level of vibration.

WRITTEN CONTRIBUTIONS

Mr. D. T. BOLTWOOD (H.Q.)

I have read the paper with great interest and personally feel that to young and relatively new Surveyors like myself, it will provide a useful reference. I should like the Author's comments on the following points: —

I would be interested to learn to what extent on these vessels radiography is carried out and what influence does the Surveyor have in the number and selection of the locations to be radiographed. Is this left entirely to the discretion of the quality control department of the shipbuilders without some reference to the Surveyors?

It appears no mention has been made of the main horizontal and vertical butt joints between units and it is wondered whether the Author has any comments of difficulties encountered in these areas. In this connection, it is thought that a useful supplement to Fig. 8 would be a sequence of erection in the longitudinal direction.

In the introduction, the Author states that when quality control begins to prove its value, the examination of all fabricated units by the Surveyor may be relaxed. Would the Author enlarge a little more on this matter and outline any general guidance which would help a Surveyor to assess when a quality control system had proved its value. It is appreciated that no rigid answer can be given.

Mr. L. BREWER (H.Q.)

It is always encouraging to see a paper which gets down to the nitty gritty of surveying which is perhaps the basic function of a Lloyd's Surveyor.

The paper should be particularly useful to the younger Surveyor in pointing out problem areas which should be doubly looked at when carrying out his final dry surveys.

With this in mind, it is thought Mr. McIntosh could have been a little more instructive when elaborating on the difficulties in some areas of construction with vessels such as the large bulk carrier type, to suggest ways and means to correct these problem areas. In some cases this has been done but in a lot of other cases only the problem has been brought to light without any mention of a cure.

It is realised, of course, that depending on the shipbuilder's enthusiasm in the aspect of quality versus economics, the Surveyor, irrespective of his experience may be hard put to persuade a builder to try alternative proposals, unless that particular shipbuilder has had first-hand knowledge of repairing costly faults to his detriment.

However, it would be interesting to learn whether Mr. McIntosh has any remedies for the problems he has put forward, irrespective of whether these were acceptable by the builder.

With regard to Mr. McIntosh's suggestion that butt weld preparations of unusual sections and heavy bulb longitudinals should be approved, does he mean that such weld preparations should be examined by the local Surveyor prior to welding or that they should be submitted to the plan approval office for approval.

My own view is that it would be beneficial to both the builder and the Surveyor if as many 'fit-up' examinations were made as possible both on site and even at the prefabrication stage.

On ships of this size, there is bound to be a fair amount of higher tensile steel fitted and I am surprised that no mention is made of difficulties encountered in welding of this material such as under-bead cracking and undesirable bead appearance. Is it to be concluded that the Author has experienced no difficulties in this area?

Furthermore, very little is said nowadays about edge hardness effect of flame cut unwelded edges of higher tensile steel and I wonder if Mr. McIntosh could relate any thoughts he may have in this matter.

Mr. P. MANSON (Newcastle)

Mr. McIntosh is to be congratulated in producing a very interesting paper, and his comments on lamellar tearing I have found of particular interest, having been involved with this problem in 1966/67, with the fabricated design of a main bearing saddle for Sulzer Engines, since discarded in favour of the cast steel or forged steel centre piece. The saddle was of rolled steel plate of 60–70 mm thickness, and several cases of lamellar tearing came to light, some very serious, one such case requiring the complete renewal of the bedplate. There was one engine maker, however, who only had one minor case of lamellar tearing, and as a result it was decided to investigate the success of the engine manufacturer against others which had failed.

In short, it came to light that after going through all normal mechanical and non-destructive tests, it was also this firms practice to carry out sulphur print tests on the end or edges of the saddle plates to determine the amount of segregates or cleanliness of the steel, and based on their standards, plates were accepted or rejected. It is my personal opinion that by ultrasonic testing alone, it is very difficult indeed to determine a dirty steel or segregations, unless of gross proportions. Laminations, of course, can be detected. Is spot checking by sulphur prints a feasible proposition for plate edges where the geometry of the joint design could well lead to lamellar tearing, or alternatively should plates used in way of tank top, and horizontal shelf plate bulkhead connections be of steel made by the electric furnace process coupled with vacuum degassing? This, if not eliminating the problem of lamellar tearing, will, I am sure, greatly reduce incidents of this kind.

Mr. McIntosh has clearly shown that unless good clean steel is available (vacuum degassed) that the geometry of joint design as shown in Fig. 12 of the paper requires careful consideration. I was rather interested to note that in the sketch of the modified arrangement shown in Fig. 12, no change had been made at the double bottom tank top connection. The Author's comments on this point would be of interest.

It has been my experience, particularly in this country, that electrodes are not always treated with the respect they are due, especially so-called low hydrogen electrodes. One can sometimes see them lying in dock bottoms, or in containers not properly designed to protect the electrodes. Even with the special heated containers for low hydrogen electrodes, lids are left open. The Author's views on this aspect would be appreciated. Some quarters specify the use of low hydrogen electrodes at joints subjected to lamellar tearing.

Access and Escapes (Fig. 16) gives a very good example of the shipbuilders arrangement for valves in pipe tunnels. Most

of us, I am sure, have been faced with situations, where valves in compliance with the Rules (to be accessible) would require the re-design of a deeper pipe tunnel, otherwise the Surveyor has to distort himself, and use mirrors to examine the valve. If a fitter can put the valve in position, then the shipbuilders attitude is that the valve is accessible for maintenance, but this is not necessarily so.

Unlike some shipbuilders, it is known that certain leading shiprepairers are having to comply with workers demands for providing access points through the holds, or bolted manhole openings in the top of the pipe tunnel. Apart from making access much easier during maintenance work, they also act as quick escapes in case of emergency. There are three alternatives which I consider to be worthy of consideration, and I would appreciate the Author's views on this sometimes vexing problem.

(1) All valves should be positioned in engine room or pump room, thus leading to an increase in the number of pipes and connections in the pipe tunnel.

(2) Access to holds through bolted covers on top of pipe tunnel. (Access only after discharge of cargo.)

(3) Access from deck through trunking at selected points, say two or three between bridge front and foremost end of pipe tunnel. These would also act as a good source of ventilation, which is in many cases poor and would also allow positioning of groups of valves adjacent to these openings from deck and provide good means of escape in case of emergencies.

In Section 8.0 (delivery); during dry-dock examination one item which I know Mr. McIntosh is well aware of, but I feel should be included for the benefit of the younger Surveyor, and that is the propeller and outside fastenings of sternbush and sea connections should be examined, and in the case of oil glands these should be checked for tightness. Clearance or gauge readings as the case may be having been verified.

AUTHOR'S REPLY

In presenting a paper on such a wide subject, it was evident that to maintain its size within a reasonable limit many topics could only be dealt with in a general manner. The Author is grateful for the excellent contributions to the discussion, in particular that by Mr. Boylan which is complementary to the paper. His comments, on the Society's future should the British shipbuilding industry be nationalised, are most reassuring.

To Mr. Boylan

Mr. Boylan's remarks on the training of new entrants at the Crawley Training Centre are of interest, but this training is mainly theoretical. The Author agrees the need for the Society to attract the best technically qualified graduates and to channel their abilities to the specialized work for which they are best suited.

In Appendix 1 it was stated that the 70 items listed were found useful for both classification and specification surveys and I regret this may have been misleading. Mr. Boylan states he found Appendix 1 terrifying, but it is not uncommon for the classification Surveyor to be responsible for statutory and crew accommodation surveys, whereupon it is his responsibility to see that all items stated are dealt with. The items which a specification services Surveyor is required to examine would far exceed those in Appendix 1.

For the sake of clarification, the items normally examined for classification requirements are: 1–23, 31–43 (freeboard marks need only be verified in item 43), 46, 49, 58–61, 67 and 68. The remainder of the items in Appendix 1 are only examined for statutory and crew accommodation surveys.

The Surveyor could not possibly afford the time to personally examine all material for surface defects and laminations and is not expected to do so. The shipbuilder has a squad of several men engaged on shot blasting and inspecting material prior to primer paint coating. When material is found to be defective it is laid aside for the Surveyor's inspection and recommendation.

U.K. shipbuilders are aware of the need for improved quality control within the industry and the introduction of quality assurance is almost inevitable. It is regretted that Mr. Phillip was unable to be present to give us the benefit of his investigations. I believe that the development of quality assurance in shipbuilding will radically change the duties of the Surveyors in the field, and the Author wholeheartedly agrees with the view that the volume of the Surveyor's paperwork should be kept to a minimum. However, the system of signing for surveys carried out has been used for a number of years now and is dealt with by the shipyard personnel. The Surveyor retains a copy of the report and this has been found most useful for logging the extent of surveys carried out and analysing the incidence of defects.

Mr Boylan has pointed out that the Outport Surveyor should not be worried, as the design problems are investigated before the scantlings are fixed. Due to oversights, or modifications, the loading conditions may be changed before the loading manual is finally submitted for approval from the longitudinal strength aspect. If the scantlings are found deficient, reinforcement may be required.

The latest addition to the Rules for Steel Ships 1974 Chapter D 3423 defines clearly the windlass tests to be carried out. They are very similar to those carried out over the last few years on the north east coast and are as follows: the time required to lift 27·5 metres (15 fathoms) from a depth of 82·5 metres (45 fathoms) has to comply with the manufacturers specification or be approximately three minutes. The same time was allowed for lifting two anchors simultaneously from a depth of 55 metres (30 fathoms). Where two independent windlasses are fitted, it is unnecessary to lift both anchors simultaneously. If the depth of water is less than 82·5 metres (45 fathoms) it is recommended that the ship should go slowly astern when running the cables out, so that they are extended along the bottom.

Mr. Boylan's comments on lack of root fusion and inefficient welding of butts in side and deck longitudinals are appreciated. The Author concurs with his remarks and would add that, where green material is required to be left on units to any great extent, it is as a result of inefficiency and incurs unnecessary expense. From experience, however, the exception to this has been found at the final join-up butts at No. 1 cargo hold and at the after oil fuel bunkers. Due to the shape of the ship in these areas, unless green material is provided, expensive cropping and renewing is required due to excessive

gaps at the deck and side shell butts.

In reply, to MR. PHILLIP'S question on sternframe and rudder alignment, some shipyards referred to in the paper have fitted pre-aligned sternframe and rudders of the simplex type. It is usual to leave the coupling bolt holes in the vertical palm of the back axle 3 millimetres less than the required diameter. Temporary bolts of smaller diameter are used at the initial lining-off stage. On completion at the berth, the bolt holes are machined to size and the correct bolts fitted. In answer to MR. PHILLIP'S request for particulars of methods used to correct misalignment, in one particular ship practically every alignment problem possible was encountered.

The following is a summary of events:—

(1) Sternframe of simplex type in 3 parts (top arch, boss, solepiece) pre-aligned at the manufacturer's works where dimensions and alignments were verified.

(2) On delivery at the shipyard, pieces were coupled up and scarves welded with the sternframe in the horizontal position and back post fitted.

(3) Backpost removed and temporary jack-bar fitted between the vertical top palm and bottom bearing (in case of damage to backpost).

(4) Sternframe erected and stern structure in way built-up by single plates, port and starboard welded simultaneously. The sternframe supported by steel wire stays with tensioning screws. Centre of boss sighted regularly.

(5) After keel blocks removed and stern freely suspended prior to boring-out boss. Jack bar removed and backpost fitted.

(6) Bottom bearing found twisted $\frac{1}{2}°$ to starboard and 15 millimetres above base line. Upper vertical palm of backpost was 62 millimetres off centre line to starboard.

(7) Sternframe manufacturers were consulted and using propane gas torches the solepiece was heated at mid-length to 900°C, rectified twist and lowered solepiece to correct line.

(8) Backpost refitted and alignment proved correct, but rudder backpost and sternframe top vertical palms were lying open 47 millimetres and the bolt holes 4 millimetres out of line vertically.

(9) A machined steel chock 47 millimetres thick fitted at top vertical palm. Diameter of bolt holes increased and new bolts fitted of slightly increased diameter.

(10) When the horizontal palm bolts were fitted the rudder stock was $\frac{1}{2}°$ out of alignment, inclined aft, requiring the steering gear seats to be lined-off to suit.

Many theories were expressed regarding the cause of the misalignment, but all were inconclusive. The above example illustrates the many areas where misalignment may occur. The Author does not necessarily agree that the methods used to rectify the faults were either the best or most efficient.

It is regretted that the publication of the Noteworthy Defects List (hull) was abandoned and it is hoped that it will again be resumed. It is an excellent means for drawing to the attention of the Surveyors the important features likely to cause trouble, whereby preventative action may be taken in ships under their survey. It is also a most useful guide to young Surveyors and I would recommend that difficulties encountered by surveyors on new construction might also be included, if surveyors can be persuaded to co-operate. (See also reply to MR. R. E. PRINCE regarding detail design in ships.)

To Mr. Beaumont

Mr. Beaumont's remarks on quality assurance are appreciated and I would add that unless the Society's Surveyors continue to play an important role in the quality control system within the shipyards, classification as we now know it today may not only change, but could become obsolete.

The lifting device in Fig. 3 illustrates an arrangement which has been used for two or three years. It was not fully explained in the paper that the arrangement shown is not for a single lift. Units up to 70 tons have been handled by fitting the eyebolt shown at the four corners of the unit. The size of units which can be lifted and the positioning of the eyebolt are dependent upon the cranage facilities available.

It was found that bulkheads tested by spraying on soapy water solution, regularly resulted in further leakage when structurally tested by water pressure. In confined spaces Surveyors and operators handling the spray gun invariably received soakings as soapy solution rebounded from the bulkhead structure.

Prevention is always better than cure and this is particularly the case with bottom shell platings. The figure of ± 3 millimetres out of plane tolerance is fairly standard, but it is rarely maintained during construction.

To Mr. Lintell-Smith

Mr. Lintell-Smith's comments on the experiments carried out at the Research Laboratory, Crawley, are of particular interest and the Author is grateful for his expansion on the metallurgical features of lamellar tearing.

It is agreed that weld preparations for unusual sections or heavy bulb longitudinals should be submitted for approval. The fit-up for these welds may vary considerably depending upon their position and the shipyard conditions, and are usually best taken care of by the local surveyor. Procedure tests are of no real value unless they are carried out under similar conditions to those encountered in practice.

The second sentence of Section 6.1 (10.2) would be more accurate if read as suggested by Mr. Lintell-Smith, i.e. "If any laminations, large inclusions or heavy concentrations of inclusions were detected, the plate was not used in this area."

In the illustration (Fig. 12), the shelf-plate was kept well clear of the radius and a fillet welded connection was used to reduce the danger of the heat affected zone occurring in the vicinity of the knuckle. Perhaps it would be prudent to ultrasonically test the area in way of the radius bulkhead plates, But it must be considered that this would entail a great deal of testing. Due to the economics of the exercise, I feel the shipbuilder would only agree to ultrasonic tests being carried out, if there was in fact evidence of lamellar tearing occurring.

Incomplete welded butts of bilge keels fall into the same category as do the incomplete welded butts of rubbing bars welded directly to the shell and both demand similar attention.

To Mr. Smith

The Author wishes to thank Mr. Smith for his comments about Mr. Coggan's paper on 'Fire Detection', recently presented to the Technical Association.

Some of the items mentioned in 'Sequence of Operation' in Appendix 1, are to be found more fully dealt with in Paper No. 4, Session 1970–71 on 'Crew Accommodation' which the Author recommends to any colleague as a reference if called upon to carry out this type of survey. In the conclusion to the paper, the Author stressed that any reference to loadline and tonnage statutory requirements was deliberately avoided,

as they had been very well covered in previous Technical Association papers and the Author apologises to Mr. Smith for omitting crew accommodation which also comes in to this category.

To Mr. Prince

Mr. Prince comments on the need for young Surveyors to be fully aware of the areas where high bending and shear stresses are likely to occur. This can probably be best achieved if new entrants spend their initial training in the plan approval departments.

In writing the paper the Author limited the subject to experiences gained during the construction of large bulk carriers and O.B.O.'s. It would be of interest if our colleagues on repair work, who regularly witness the results of failures in service were to pass on their experiences in a similar paper.

In recent years scantlings of ships have been reduced to the point where the field Surveyor is no longer in a position to make on the spot decisions, when local modifications to main structural members are necessary. The young Surveyor, if in doubt, should never hesitate to seek the advice of a senior colleague or refer the matter to the Plan Approval Department.

The booklet issued in 1967, 'Detail Design in Ships', has stood the test of time very well and is still of value, but recent changes in size, type and design of ships, and the rapid progress that has taken place in the development of new shipbuilding techniques, warrants an updating of this booklet.

To Mr. Farrell

Mr. Farrell's description of the disastrous effects that can result from lack of proper control and supervision, is a first class recommendation for the need for an efficient quality control system. The word efficient is stressed, because, all too often it is found that a quality control department, although well aware of bad practices, poor procedures, lack of facilities and inefficient methods employed are unable to rectify them.

The Author, personally, feels that there is no reason why large ships should be defect-prone, providing the method of construction is carefully planned, adequate staging provided at the ship join-up butts and seams, and strict supervision is maintained by both the shipyard personnel and classification Surveyors. Providing the inspection standards are efficient and the design carefully planned, the Author sees no technical limit to the size of ship that can be built. The only thing actually limiting the size of bulk carriers would appear to be the physical limitations of the port facilities and sea routes.

To Mr. Gray

In the body of the paper the Author expressed the hope that the paper would be of interest to younger members and new entrants to the Society and also Engineer Surveyors who may find themselves engaged on ship surveys. The Author notes with particular pleasure that Mr. Gray, who describes himself simply as an electrical engineer, has contributed to the discussion.

Dealing with points (a), (b) and (c) collectively; as Mr. Gray states, they are in themselves minor, however they may be very misleading to the new entrant and the Author is grateful to Mr. Gray for pointing this out. All three points relate to inspections at the panel-line stage and the Surveyor is not expected to meticulously examine every detail. Daily inspections are carried out which may last from five minutes to half an hour, depending upon the work being prepared and the Surveyor's programme for that day. Short daily visits are enough to ensure that a good standard is maintained on the items detailed in Section 4, items 1–9.

The Surveyor receives copies of the approved drawings which have been approved mainly for scantlings only. He does not receive copies of the working drawings although copies are available for his use at the panel line assembly office. These plans should be examined against the first unit of any series. On large ships there is a great deal of repetition and it is necessary to ensure that all openings, notches, etc., have been properly burned-out. If they are not, the defects are brought to the attention of the production manager for correction, otherwise the same mistakes or omissions may occur from 20 to 200 times in subsequent units. The Surveyor is not required to be experienced in programming and preparing tapes.

The hull specification normally states that defects or modifications are to be mutually agreed upon by the owner's superintendent (may be L.R. Specification Services) and the classification Surveyor. Some company superintendents refuse to accept cropping and part renewing deck or shell plates, although this may be quite acceptable to the classification Surveyor. There is never any question of the classification Surveyor passing the buck.

In the Author's experience any constructive criticism on defects if brought to the middle managements notice at an early stage, is usually appreciated. The remarks in Mr. Nilsson's paper in 1969 were specifically directed towards the speed of ship construction in Sweden. Obviously the same level of production has not yet been attained on the north-east coast. Practically every unit is examined by the Surveyor, prior to erection on the berth and any recommendations made are usually dealt with along with those of the quality control inspectors.

Vibration is a very complex subject and the first thing to be determined is the type of vibration we are dealing with, be it propeller or main-engine excited or local hull vibration. An excellent paper on this subject was presented to the Technical Association by Mr. A. R. Hinson (1960–61—Paper 2).

Vibration tests vary radically between shipbuilders, but a typical example is as follows:—

During sea trials an experienced member of the quality control team carries out measurements at various predetermined areas which, from past experience, have proved susceptible. Both vibration amplitude and noise levels are recorded using a vibration analyser and a precision sound level indicator. Additional readings are carried out at the discretion of the Surveyor.

The results obtained are analysed and compared against figures for a similar type of ship. If the readings are found to be in excess of the range specified, they are brought to the attention of the Surveyor. Very often the use of a meter is unncessary as the structure under consideration can be clearly seen to be vibrating and in need of attention. In the Author's opinion, the Surveyor is not in a position to demand that vibration levels be reduced. He should, however, recommend to the shipbuilder what he considers to be the best action to be taken to reduce the vibration to an acceptable level. On local hull structures this is usually achieved by fitting stiffening or additional pillar supports. On occasions where serious hull vibration has been experienced and has proved beyond the capabilities of the local Surveyor, the Society's Technical

Investigation Department has assisted.

If a ship is built in accordance with the Society's Rules but unfortunately is found to suffer from vibration problems the Author does not agree that classification should be refused. Some owners have carried out every recommendation which on occasion, has resulted in costly modifications, only to find that the vibration has continued, in some cases for a number of years. It appears unjust under such circumstances to withhold a ship's class.

To Mr. Manson

Mr. Manson has raised some very interesting points and his experiences of lamellar tearing in main bearing saddles of Sulzer engines are of particular interest.

Spot checks by sulphur prints, in way of the shelf plates exposed edges would be quite feasible, but the Author feels that the extent of the area to be covered in a ship of this size would make it impracticable. Either magnetic particle, dye penetrant or ultrasonic testing methods are quicker and enable full coverage of the areas to be examined. It is agreed that the solution to the problem of lamellar tearing is to use only good clean steel (vacuum degassed). During the construction of some of the ships, 100 per cent ultrasonic inspection was carried out on the double bottom tank top plating, in way of the transverse stools. Care was taken to ensure that the steel was free from laminations, large inclusions or heavy concentrations of inclusions. A German shipyard with a similar problem introduced a cruciform casting at the junction of the tank top and bottom of the bulkhead stools. As stated by MR. R. R. LINTELL-SMITH, this was not a success, due to metalurgical reasons. Some shipbuilders have now replaced the lower wing tank/double bottom tank top connection with a radiussed plate.

The Author regrets to agree that most shipyards could improve their methods of storing electrodes prior to use. In large ships maximum use is made of machine welding resulting in less trouble. The advantages of using low hydrogen electrodes, on joints subjected to lamellar tearing, may be outweighed by the increased porosity and manual welding difficulties which may be incurred. There are also restrictions on the use of low hydrogen electrodes in enclosed spaces, for health reasons.

Access and escape is a subject that affects the Ship Surveyor daily and deserves serious consideration. The Author would like to see the distance between access openings to pipe tunnels limited to 40 metres or two hold spaces in length. Where transverse cellular bulkheads are fitted, one—preferably at midships—should be fitted with a mechanical lift from the pipe tunnel to the upper deck.

In reply to Mr. Manson's itemised proposals regarding access:—

(1) This would increase the number of pipes and connections in the tunnels and they would still require to be examined and tested.

(2) Manholes are not recommended in water ballast holds where, if inadvertently left open or not effectively closed could result in serious flooding of the pipe tunnels and possibly the machinery space. Manholes are not likely to be fitted in holds where grabs are to be used for discharging.

(3) These are excellent recommendations which the Author would like to see enforced.

The Author agrees that propeller and outside fastenings of the sternbush and sea connections should be examined, and in the case of oil glands, these should be checked for tightness. At the initial drydock survey the items mentioned are normally examined by the Engineer Surveyor, but on subsequent surveys become the responsibility of the Ship Surveyor.

To Mr. Boltwood

The extent of radiographic inspection carried out on bulk carriers is fairly standard and should comply with the requirements of Section D 2305 of the Rules for Steel Ships. Shipyards in the north-east area also radiograph random butt welds of shell, deck and wing tank longitudinals. Spot checks are also made on the bottom shell plating butts and seams at the forward panting area and in way of any temporary shell access openings. The co-operation of a qualified radiographer is of considerable assistance to the Surveyor, as he will have carefully assessed all radiographs before the Surveyor carries out his examination.

A common fault at the main horizontal and vertical butt joints, is mentioned in Section 5.1, Item 9, i.e. fractures which result at the cruciform, due to lack of root fusion at the ends of machine welded seams. Another common failing is where ends of welded seams are left proud, resulting in poor fit-up and very often heavy slag inclusions.

The sequence of erection in the longitudinal direction depends upon a number of factors, e.g. availability of labour, lifting arrangements and berth facilities. Some ships are constructed in two parts and joined together in drydock. The shipbuilder prepares a plan of sequence of erection which is also used as the plan of sequence of welding (Section 6) and submits it to the local surveyor for approval. The main consideration in approving this plan, is to see that any locked in stresses due to incorrect welding sequence is avoided and that welding is progressed to a free end, the units being pulled in systematically.

It would be imprudent for the Author to comment on how quality control is to be assessed, at this time. Mr. Boylan in his comments states that the Society is giving very serious consideration to this subject and it is hoped that official instructions will be published in the near future. Before this occurs the Author would personally like to see a list of tolerances published as a guide for all Surveyors throughout the Society. This would help to prevent any shipbuilder gaining an unfair advantage over his competitors due to inconsistency between Surveyors.

To Mr. Brewer

As previously mentioned in the opening reply, in endeavouring to limit the size of the paper some items were dealt with in only a general manner. The method of dealing with some of the difficulties encountered during erection were not elaborated upon. As the purpose of the paper was to bring them to the notice of the younger Surveyor. The solution to the problems are proposed by the shipbuilder and the agreement of the Surveyor sought. The solutions proposed need not, however, be the only suitable method, nor the best way of dealing with the problem. As Mr. Brewer states, the Surveyor may be hard put to persuade the builders to adopt an alternative proposal. It is true to say, however, that the standard of work, produced in the respective shipyards, is greatly influenced by the vigilance and attitude of the Surveyor resident there.

The majority of defects illustrated in Section 6 (Erection on Berth) result from poor fit-up or wrong sequence of welding procedures. The cure for this is to improve the standard of the inspection department and to operate an efficient quality control department.

Higher tensile steel is used extensively on large bulk carriers and many difficulties in welding the material have been encountered. The defects mentioned by Mr. Brewer, are met regularly and the shipbuilder's technical welding manager spends a great deal of time testing new methods, electrodes and machines to find the best combinations for eliminating these and the other defects met with daily.

Although less may be heard nowadays about the edge hardness effect of flame cut unwelded edges, it is, nevertheless, still very much with us. Where longitudinals are cut from plate material by flame cutting, the free edge is ground smooth and the corners rounded. The 'old chestnut' which is regularly raised, is should the edge of the upper deck plating inside the line of the upper deck hatch coamings be ground smooth and the corners rounded? In this area, it has been the practice to grind only the deck edge in way of the hatch corners, and I am not aware of any serious trouble as a consequence.

ERRATUM

To Paper No. 2 Session 1974–75

by

G. S. McIntosh

Page 13, Item No. 44—line 3 should read:

one man per two steps

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Lloyd's Register Technical Association

SOME NOTES ON WRITING DAMAGE REPORTS

L. D. Phillip

Paper No. 3. Session 1974-75

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Hon. Sec. A. Wardle
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TABLE OF CONTENTS

Section 1 INTRODUCTION

Section 2 CONDITIONS OF INSURANCE
- 2.1 Particular average
- 2.2 General average
- 2.3 Protection and indemnity insurance
- 2.4 Shipbuilders and shiprepairers insurance
- 2.5 Towage insurance
- 2.6 Loss of earnings or loss of hire insurances

Section 3 TERMS USED IN MARINE INSURANCE
- 3.1 Stranding and grounding
- 3.2 Fire
- 3.3 Collision
- 3.4 Striking
- 3.5 Contact with non-navigable objects
- 3.6 Sunk
- 3.7 Latent defect
- 3.8 Heavy weather
- 3.9 Negligence
- 3.10 Port of refuge
- 3.11 Wear and tear

Section 4 LONDON SALVAGE SURVEY INSTRUCTIONS
- 4.1 General
- 4.2 Instruction one
- 4.3 Instruction two
- 4.4 Instruction three
- 4.5 Instruction four
- 4.6 Instruction five
- 4.7 Instruction six
- 4.8 Instruction seven
- 4.9 Instruction eight
- 4.10 Preliminary reports

Section 5 UNITED STATES SALVAGE SURVEY INSTRUCTIONS

Section 6 PARTICULAR ASPECTS OF DAMAGE REPAIRS
- 6.1 Painting
- 6.2 Deferred repairs
- 6.3 Temporary repairs
- 6.4 Estimated costs
- 6.5 Tenders for damage repairs
- 6.6 Repairs effected prior to survey
- 6.7 Schedules of prices

Section 7 THE SURVEY REPORT
- 7.1 General
- 7.2 The survey report (London Salvage)
- 7.3 The survey report (United States Salvage)
- 7.4 Field survey report (United States Salvage)

Section 8 GENERAL DUTIES OF THE SURVEYOR

Section 9 CONCLUSION

ACKNOWLEDGEMENTS

REFERENCES

BIBLIOGRAPHY

APPENDIX 1 London Salvage damage report (accounts available)

APPENDIX 2 London Salvage damage report (accounts not available)

APPENDIX 3 Special addendum to London Salvage damage report (when accounts become available)

APPENDIX 4 United States Salvage damage report—contact damage

APPENDIX 5 United States Salvage field survey report—contact damage

APPENDIX 6 United States Salvage damage report—stranding damage

APPENDIX 7 United States Salvage field survey report—stranding damage

APPENDIX 8 United States Salvage field survey report—common charges

APPENDIX 9 United States Salvage memorandum of separation of damage

APPENDIX 10 Specimen damage report for owners

APPENDIX 11 Survey data list

SOME NOTES ON WRITING DAMAGE REPORTS

by L. D. PHILLIP*

1 INTRODUCTION

The purpose of writing this paper for presentation to the Technical Association is two-fold:

(a) to introduce the younger Surveyor to this type of work and to assist him in carrying out the survey and in writing the report,

(b) to encourage a consistent method of procedure and presentation of damage reporting which will supply the information required by underwriters in a manner which will enable him to deal with the claim correctly and according to the conditions of insurance.

As a further aid to the Surveyor not familiar with the subject, some examples of typical damage reports, field survey reports and memoranda, as listed in the Appendix, have been prepared and are set forth in the manner and detail required by both London Salvage and United States Salvage Association. A damage report in the form generally required by owners is also provided together with a survey data list.

The purpose of a damage survey is to produce a report which will serve to guide the average adjuster in deciding whether or not a claim falls within the scope of the insurance and, if so, to assist in the apportionment of the details of work and costs involved in the respective policies. A careful choice of words is required and it is particularly necessary to differentiate between factual details and reported information.

It will be obvious to those reading the report whether or not a Surveyor has taken care to ensure clarity. Attention to detail and a little extra effort on the part of the Surveyor will create enthusiasm in the reader for the Surveyor's efforts and reflect favourably on the organisation he represents. The report will be judged by the degree to which it meets the requirement of underwriters.

Little opportunity is afforded the Society's Surveyor in the U.K. to become familiar with this aspect of surveying and writing of damage reports, as this work is usually carried out by the Salvage Association surveyor or by a consultant surveyor representing 'Salvage'. In ports abroad, however, where there are no Salvage Association surveyors and few recognised consultant surveyors, the Society frequently is appointed by The Salvage Association, London or the United States Salvage Association Inc., through the local Lloyd's Agent, to carry out and report upon damage sustained by ships and, occasionally, even by land-based structures. Instructions to carry out these surveys are issued by Salvage to Lloyd's Agents at the port of survey, who then appoint the Surveyor. These instructions require to be clearly understood and carried out with a minimum of delay.

2 CONDITIONS OF INSURANCE

Conditions of insurance are of the utmost importance to adjusters and underwriters: they do also, however, have some significance to the Surveyor and a knowledge of these conditions will assist him to obtain all relevant facts and probable costs. The information gathered at the survey will permit preparation of a survey report which will supply the data required by underwriters. The information required by underwriters falls under two headings—particular and general Average. Both these terms imply different forms of partial loss to which all maritime adventures are exposed and against which the owners of the property at risk protect themselves by insurance.

2.1 Particular average

According to the *Marine Insurance Act*, 1906, Section 64(1), "A particular average loss is a partial loss of the subject matter insured, caused by a peril insured against, and which is not at general average loss".

The principle risks covered by marine insurance described as the 'maritime perils insured against' include the following:

(1) Perils of the sea, e.g. heavy weather, grounding, stranding, collision, striking of structures, derelicts, ice and floating or submerged objects.

(2) War Risks (generally excluded by a special clause, except at an additional premium).

(3) Fire.

(4) Barratry (a wrongful act wilfully committed by the Master or crew to the prejudice of the owner or charterer).

(5) Explosions.

(6) Bursting of boilers.

(7) Breakage of propeller shafts.

(8) Latent defects.

(9) Negligence of ship repairers and of Master, mariners, engineers or pilots.

(10) Stevedore and other cargo handling accidents.

(11) Electrical breakdowns.

(12) And any other perils, either of a like kind or which may be designated by the policy.

2.2 General average

According to the *Marine Insurance Act*, 1906, Section 66:

(1) A general average loss is a loss caused by or directly consequential on a general average act. It includes a general average expenditure as well as a general average sacrifice.

(2) There is a general average act where any extraordinary sacrifice or expenditure is voluntarily and reasonably made or incurred in time of peril for the purpose of preserving the property imperilled in the common adventure.

(3) Where there is a general average loss, the party on whom it falls is entitled, subject to the conditions imposed by maritime law, to a rateable contribution from the other parties interested, and such contribution is called a general average contribution.

The following are some of the more common examples of general average losses:

(1) Damage to a ship's hull and appendages and equipment in refloating a stranded vessel.

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(2) Damage to engines, auxiliaries, shaft bushings, and fuel consumed in refloating a stranded vessel.

(3) Damage to the ship(s) in the efforts made to extricate one from the other subsequent to a collision.

(4) Damage to a ship in the efforts made to extinguish a fire on board by the use of water, steam, etc., and by cutting holes in the deck or side plating, etc.

(5) To effect repairs at a port of loading, call or refuge, necessary for the safe prosecution of the voyage.

(6) Chain cable and anchors slipped to avert a threatening peril.

Particular average loss therefore may be contrasted with a general average loss in that the former is accidental, while a general average loss is the result of a deliberate and voluntary act. For example, both the ship and cargo may be damaged, say, by heavy weather at the same time, but the damage to each is accidental and 'lies where it falls'. There is no sharing of one man's loss by the other as in the case of a general average act performed to save all from disaster.

It should be noted, however, that when a general average situation arises, shipowners, underwriters or adjusters may request that the damages and costs in the report be separated into various catagories. For example, if a vessel strands, there may be specific items of damage resulting from efforts to refloat; or if a vessel is on fire there may be damages resultant from efforts to extinguish a fire. In both these circumstances the damage actually caused by the strand or by the fire must be separated from the damage peculiar to the refloating or extinguishing efforts. In cases of doubt no attempt at separation is to be made in the report. It is essential therefore, that the Surveyor takes sufficient notes at the time of the survey in order to make a separation along the lines of the foregoing.

It should be clearly understood that in the course of bill approval, separation is also necessary in the matter of costs. At the survey and where all in attendance are in agreement with the suggested separation of damage into primary, secondary and/or later causes, the memorandum attached to the report, or the report proper, should indicate that agreement was reached.

In all cases of doubt, it should be clearly borne in mind that the essential element of a general average loss, be it a sacrifice or an expenditure, is that of 'giving' for the benefit of all. The loss that follows must be such as might reasonably have been anticipated at the time of the sacrifice. To quote from the *York Antwerp Rules*, 1950, Rule 'C', "Only such losses, damages or expenses which are the direct consequence of the general average act shall be allowed as general average. Damage or loss sustained by the ship or cargo through delay on the voyage, and indirect loss from the same cause, such as demurrage and loss of market, shall not be admitted as general average".

2.3 Protection and indemnity insurance

Commonly known as 'P & I', this insurance covers a shipowner's liability for damage to harbours, docks, piers, quays, jetties, buoys, bridges, telegraph cables, etc., and is in fact protection against damage to any object fixed or movable except another vessel or craft, or property on another vessel or craft which may be caused by his vessel or vessels.

2.4 Shipbuilders and shiprepairers insurance

These insurances protect the builder or repairer against accidental damage to the ship whilst building or in the process of repair and certain liabilities which a builder or repairer may incur when the vessel is within his control and custody, e.g. faulty workmanship, faulty materials and perhaps design. It should be noted that when the repairs of this accidental damage are made by the builder or the repairer he is entitled to reimbursement but only for the cost of labour and material; profit and indirect overheads are not included. Overheads directly applicable to the repair may be included in the repair costs.

However, when repairs are carried out by a contractor other than the assured, the contractor is entitled to all normal costs plus a fair and reasonable profit.

2.5 Towage insurance

The 'Standard Towers Policy' protects the owner of a towing vessel in the event that the vessel or its tow is responsible for a collision, or in the event the tow itself is damaged in a collision, striking or grounding.

2.6 Loss of earnings or loss of hire insurances

Loss of earnings underwriters are concerned with ships on which time is lost by reason of damages which have resulted from perils and other circumstances insured against under the standard hull policy.

As the underwriters are interested in time lost by a vessel having to be surveyed and perhaps repaired due to a casualty and therefore having to be taken from its normal operation, the survey report should contain the following information:

The time and date of:

(a) The diversion of the vessel from its regular trade route and position where the vessel deviated.

(b) The arrival of the vessel at a repair yard or similar facility.

(c) The commencement of the survey and the conclusion of the survey.

(d) The commencement of repairs and the conclusion of repairs.

(e) The return of the vessel to its original trade as interrupted by the casualty.

(f) The time saved by overtime, extra-Sunday shifts, etc.

In stranding cases the Surveyor is required to report details of the time of grounding, time of refloating, time of the vessel's re-deployment in its original trade and any other relevant dates and/or times. Diversion time should include such items as cargo discharging, steaming and cleaning, etc.

The Surveyor will be expected to state details of the damage found and recommendations made for repair, but he will not be required to enter into price negotiations with the repairers, and this fact should be stated in the survey report together with his opinion as to whether or not the time to carry out the repairs is reasonable. If, in the Surveyor's opinion, an excessive amount of time was taken to effect the repairs recommended, then this should be indicated in his report, and a separate memorandum or letter attached to the report stating his opinion as to the time the repairs should have taken. The report should also contain full details of owner's work carried out concurrently with the damage repairs or at any time during the diversion period and the time taken to carry out these repairs.

It is impossible to enumerate all the risks covered by modern policies, which vary so materially with the type of insurance effected, but it should be noted that the loss sus-

tained falls under two headings, particular average and general average.

3 TERMS USED IN MARINE INSURANCE

The following information defines the various insurance terms which will no doubt be encountered in damage survey work. The descriptions are phrased in broad general terms only.

3.1 Stranding and grounding

In Marine Insurance, there is a technical distinction between 'stranding' and 'grounding' and, when reporting, care should be taken with the use of the term 'stranding', the precise determination of which is left to underwriters and adjusters. Generally a strand occurs when a vessel grounds outside the usual navigable channel. It is not a strand if a vessel grounds in the usual channel because of a shortage of water, or if the vessel takes the ground in her discharging berth in the normal way. It would, however, be considered a strand, if, during a flood, wreckage was washed into the vessel's normal berth, where it is customary to ground on the fall of the tide, and damage is sustained by sitting on the wreckage. A vessel is considered to be stranded when she contacts the ground or other obstruction in an unusual place or manner and remains held fast upon it. A grounding, on the other hand, is considered a striking of the ground in more of 'a touch and go' manner.

No definite period of time has yet been judicially determined during which it is necessary for a vessel to remain aground before it is termed as being 'stranded'. It should be noted that throughout the world there are specific places, e.g. the Panama and Suez Canals, where, if a vessel takes the ground, it is not considered a stranding.

Adjusters, in dealing with damage to a vessel alleged due to stranding/grounding, always enquire as to the prime cause of the casualty, the time of contact and exact place in which the vessel took the ground and the time the vessel was refloated. It is therefore necessary for the Surveyor to set forth all the pertinent facts surrounding the casualty with the incident being considered as a grounding.

3.2 Fire

The latter remarks concerning stranding/grounding may broadly be applied to fire damage. Some repair may be necessary due to fire only whilst some sacrifice may have been voluntarily made, such as, cutting holes in undamaged structure for the insertion of hoses to reach the seat of the fire in efforts to save ship and cargo, and segregation of these items is required in the report.

In both grounding/stranding and fire cases, it may be that certain items are common to both particular and general average and these should be shown in the report under a further heading indicating what percentage applies to the accident and what percentage to the efforts to minimise damage or rescue the vessel from the consequences of the accident.

3.3 Collision

The term 'collision' is employed to describe the coming together of two or more ships or vessels. It is immaterial that either or both of the vessels may be secured to a wharf, be at anchor, or even grounded or stranded at the time of the casualty. The striking of a quay or buoy, however, is not a collision within the meaning of the term.

When a Surveyor is requested to attend a vessel which has collided, it is very important that the question of liability be ignored as the Surveyor is not concerned in the responsibility for the collision.

In a collision between ship A and ship B and when acting on behalf of Underwriters on ship A, the Surveyor is required to obtain all possible information leading to the accident, viz. date, time and place, course, speed, weather conditions at the time of the collision, whether in loaded, part loaded, or in ballast condition, avoiding action taken, if any, draughts forward and aft, etc. Particular attention should be paid to the angle of blow and the alleged speed of the respective vessels and all this information should be included in the report. Sketches showing the positions of each vessel at the time of the collision are always useful in this respect. It is customary to have photographs taken of the damage to ship A and the Surveyor should recommend this to the owner's representative.

Normally, the information noted is restricted to the damage which the Surveyor can see which includes depths of penetration, the manner in which plates are torn and curled, the shape of fractures, score marks and their direction, and other physical evidence which, when developed, may indicate the speed and heading of the vessels involved.

The Surveyor should always bear in mind that every collision case can develop into a legal contest in which the Surveyor may appear as a witness in court to attest to his survey, and particular care must be exercised in the examination and reporting of information obtained.

However, if the Surveyor is surveying ship B on behalf of those concerned in ship A, the survey must be held, and reported, without prejudice, and the Surveyor has no authority to recommend any course of action nor to examine the log books of ship B. His duties will consist of reporting in the fullest detail possible, the course of action being taken in respect of ship B and if he notes any inclusions which, in his opinion, are not associated with the alleged collision, he will state so.

The time factor is very important in collision cases where claims for demurrage may be involved and the Surveyor should see that repairs to the alleged collision damage are carried out. The Surveyor should state whether such work had the effect of protracting the repairs and should state in his report how long the alleged collision damage repairs would have taken if effected alone. If the repairs involved drydock hire, he should state also how much drydock time was required, e.g. if the vessel could have undocked when underwater work was completed and the remainder dealt with afloat.

In collision cases the word 'struck' should not be used, but rather the words 'collision with' or 'collided with' should be used. The word 'struck' implies liability and is to be avoided absolutely. A 'striking' by definition does not imply the coming together of vessels.

3.4 Striking

A striking occurs when a vessel strikes against anything except another vessel or the bottom of the sea. The term embraces 'contacts' other than collisions, strandings and groundings.

3.5 Contact with non-navigable objects

It sometimes happens that claims under this heading are excluded from an ordinary policy and are covered separately under a protection and indemnity (P & I) policy, or it may be

that, if covered under this heading, the owner has contracted to pay some proportion of each and every claim.

The Surveyor may not be aware of the conditions but, as with all other claims, he should be careful to study the facts. He may be asked to note a large area of damage as being the consequence of one accident; examination of that area may show evidence of new contact in one place and adjacent areas possibly indented but appearing to have occurred at an earlier date. He should report how much he considers attributable to the new contact.

The Surveyor should note that when carrying out survey work of a protection and indemnity nature he is required to include in his report the general condition (apart from the damage) of the jetty, quay, buoy, etc., and at the survey the Surveyor should endeavour to reach an agreement as to the percentage that the structure depreciated, prior to damage, from general service, wear and tear, etc. Such agreement, if obtained, is to be noted in the damage report, but if agreement is not reached, then the Surveyor, in a separate letter or memorandum, is to furnish his opinion as to the amount the structure has depreciated.

3.6 Sunk

In considering the meaning of the word 'sunk', it has been held that, where a vessel, loaded with timber, had leaked and had become submerged to her decks, she was not sunk within the meaning of the word. A vessel would be considered as sunk if, through leakage, she ceased to be waterborne and was resting on the ground.

3.7 Latent defect

A latent defect is a defect which could not have been detected or anticipated by due diligence on the part of the owner. If some part of the vessel fails due to a latent defect, the owner may be able to recover the consequences of this defect but not the part itself; for example, a tailshaft breakage resulting in the loss of a propeller. If the tailshaft breakage was due to a latent defect, the loss of the propeller, being the consequence of the breakage may, in appropriate circumstances, be recovered under this policy.

Latent defects frequently occur in forgings and castings, such as shafting, piston rods, cylinders, sternframes, etc. The term does not include defective workmanship, e.g. poor riveting, badly fitting stern glands, loose keys in shafting, poor machining, etc. Fatigue may not be considered a latent condition even though it is imperceptible.

When a 'latent defect' is the alleged or suspected cause of a damage it is necessary that the Surveyor attending, separates the costs specific to the repair or renewal and the installation of the part containing the 'latent defect' from the other costs of repairs (consequential damage) arising from the casualty.

Where it is established, or alleged, that a latent defect was the cause of the damage, the costs should be agreed by the owner, or his representative, and approved by the Surveyor attending. When these costs are not agreed the Surveyor attending should make an estimate for submission to underwriters.

The cost of repair in connection with a latent defect case should be broken down as follows:

(1) The cost of renewal or repair of the defective part.
(2) The cost of repair of the damage resulting from the failure of the part containing the latent defect (consequential damage).
(3) The costs common to the installation of the defective part and to the repair of the consequential damage, i.e. opening and closing.

In some cases it is most difficult to establish the cause of the failure, as often the evidence is destroyed and in such instances the facts should be recorded in the report. The three-part cost breakdown should only be included in the survey report when, in spite of destroyed evidence, the owner persists in presenting the matter as a latent defect in a particular part. The Surveyor should set forth his opinion as to the cause of the damage in a separate letter or memorandum which covers no other subject.

3.8 Heavy weather

It will be appreciated that various items may be claimed under this heading. The Surveyor should carefully consider whether the items drawn to his attention may reasonably have been damaged by the heavy weather alleged, whether it is the product of accumulated heavy weather or whether it is due to some other cause. While examining the log books in this connection, the Surveyor should pay attention to wind forces, as, in broad terms, the state of the weather may be regarded as 'Heavy' if the wind force is 7 or over on the Beaufort scale, and the Surveyor would naturally be suspicious if a vast amount of damage was claimed when possibly the log book disclosed perhaps half a day only with wind force 6 to 7. The Surveyor must, however, record all damage claimed and if he does not agree with any items claimed he must say so in the report.

3.9 Negligence

This term is also extremely difficult to define. In simple terms it may be said that, if the Surveyor is confronted with a claim under this heading, he will require to consider whether that which is claimed was in good condition before the alleged negligence and ceased to be in good condition solely by want of due diligence on the part of the crew. It could happen that some item was actually in poor condition, in fact in such a condition that all diligence possible could not have averted failure of the item so that lack of diligence did not, in fact, contribute to eventual failure. It should be specially noted that ignorance, incompetence and negligence are not the same thing, and, if the crew are not qualified, this may be relevant.

The scope for claiming under this heading is wide and sometimes ingenious reasons are put forward to support the claim, but the Surveyor will draw upon his technical knowledge in considering how well-founded such a claim may be.

When crew negligence is involved the cause of the casualty should always be referred to as 'alleged negligence of crew'.

3.10 Port of refuge

If a vessel enters a port of refuge due to damage the Surveyor should include the following information in his report:

(1) The time and position where vessel deviated.
(2) Time to reach the port of refuge, duration of stay in port and estimated time to return to point of deviation.
(3) Amounts of fuel, lubricating oil, etc., and stores consumed from the time the vessel deviated to the port of refuge until its return to the position of deviation.
(4) Costs of tugs, pilotage, wharfage, etc.

3.11 Wear and tear

If the Surveyor is of the opinion that what he has seen was the consequence of wear and tear he must say so in the report.

4 LONDON SALVAGE SURVEY INSTRUCTIONS

4.1 General

When the Society's Surveyors are appointed by Salvage to survey damage they should at all times be guided by the relevant notes in the Society's *Instructions to Surveyors* and it is the intention to enlarge upon and supplement these instructions to enable the Surveyors to report all relevant and essential details to the Principals concerned.

When appointed to act on behalf of underwriters, the Surveyor will receive instructions as to the purpose of the survey to be held and it is most important that these instructions are carried out as directed and as soon as possible.

From London Salvage Association the local Lloyd's Agent will receive printed and numbered instructions. These instructions are numbered one to eleven and in each of these a short explanation of the details to be reported is contained. These instructions are as follows:

Instruction one — Standard damage survey.

Instruction two — Damage to colliding vessel.

Instruction three — Vessel aground.

Instruction four — Vessel sunk.

Instruction five — Fire damage.

Instruction six — Loss of anchor and cable.

Instruction seven — Casualty to vessel insured on T.L.O. conditions. (T.L.O.—Total Loss Only.)

Instruction eight — Shortage of bunkers.

Instruction nine, ten and eleven to Lloyd's Agents, explain how to deal with damage reports, etc.

4.2 Instruction one — standard damage survey

This is a standard type requiring a survey in port in respect of miscellaneous types of hull and machinery damage. This instruction states that if the vessel is at its destination port it is not necessary to furnish an estimate of the time involved to effect repairs, but, if the survey is being conducted at an intermediate port or port of refuge, the estimated period of the repair should be cabled. If damage has been sustained to the machinery, special attention is to be paid to the cause. It is important that the Surveyor establishes the prime cause. This information must be included in the final cabled advice to Salvage.

This instruction requires the Surveyor to obtain the following information and to advise Salvage by cable through the local Lloyd's Agent:

(a) Nature, cause and extent of damage.

(b) The course owners propose to adopt regarding repairs and the Surveyor's recommendations.

(c) The Surveyor's estimate of costs involved in effecting repairs.

4.3 Instruction two — damage to colliding vessel

The Surveyor is required to survey the vessel with which the insured vessel was in collision on behalf of those concerned in the latter. When both vessels are present instructions one and two will be received, and it is in order for the same Surveyor to survey both the insured and the colliding vessel, but should instructions be received to act on behalf of the underwriters insuring each of the vessels, it is imperative that separate Surveyors are appointed to represent each interest. As already mentioned, Lloyd's Agents are empowered to appoint Surveyors on behalf of underwriters and when cases arise where two of the Society's Surveyors from the same office are required to attend, on behalf of underwriters insuring each vessel, it may be prudent to receive confirmation from underwriters that this appointment is in order. This arrangement is sometimes acceptable when other independent Surveyors are not available.

Whilst surveying a colliding vessel, the Surveyor should not comment on the circumstances of the collision nor approve or endorse repair accounts, but report only the nature of the damage together with his estimates of costs involved and the estimated time required regardless of whether or not the vessel is at destination port. The Surveyor should not make recommendations to owner's representatives as to how the repairs should be dealt with. In surveys of colliding vessels the Surveyor should report on whether, and to what extent, repairs to the collision damage constitute an improvement; for instance when a damaged plate which, prior to the collision, had already wasted to a serious degree, is replaced. This is necessary because different considerations apply in dealing with liability for damages suffered as a result of collision between the two vessels and damages which form a claim under a marine insurance policy which does not require any deductions 'new for old'.

4.4 Instruction three — vessel aground

This case requires the appointment of a Surveyor specially qualified in salvage work. However, after the vessel is refloated and is available for survey, an 'instruction one' would normally be issued, but, in this instance, it is important that damages attributable to the following cases be reported separately.

(a) Damage directly attributable to the grounding.

(b) Damage directly attributable to efforts to refloat.

Special attention should be paid to machinery damage alleged to have resulted from efforts to refloat. It is also important to distinguish any damage which may have existed prior to the grounding.

4.5 Instruction four — vessel sunk

In this case the services of a qualified Salvage Officer are required. Should the vessel be refloated, however, then an instruction one would be issued.

4.6 Instruction five — fire damage

This case requires the Surveyor to ascertain the circumstances of the fire, the nature and extent of it, the course owners propose to adopt regarding repairs and the estimate of cost and time involved in effecting those repairs. It is important that the Surveyor separates any damage attributable to extinguishing operations and that he endeavours to ascertain the prime cause of the fire.

4.7 Instruction six — loss of anchor and cable

This instruction is issued to the salvors of the lost property. The Surveyor, if appointed, requires to advise on position of loss, depth of water and recovery prospects.

4.8 Instruction seven — casualty to vessel insured on 'constructive total loss' conditions (including salvage charges)

This instruction requires the Surveyor to obtain accurate estimates for salvage operations and also repair costs at the survey port and advise the Lloyd's Agent immediately. Should the costs of salvage and repairs be in excess of the insured value then the underwriters can make alternative arrangements.

4.9 Instruction eight — shortage of bunkers

In this instruction the Surveyor is requested to investigate the circumstances of the fuel shortage and ascertain the amount of fuel on board at the commencement of the voyage. The condition of the fuel tanks including the sludge content and the quantity and if any fuel was obtained at an intermediate port, should be noted. The average daily fuel consumption and speeds on three previous voyages should be ascertained. It is important the Surveyor investigates and reports fully in respect of the condition of the vessel's boilers and, as far as can be seen, the condition of the outer surface of the vessel's hull (clean or foul). The Surveyor should also note oil fuel tank capacities, weight of cargo and water on board, vessel's draughts on leaving last port and weather conditions during the passage.

4.10 Preliminary reports

Salvage require early replies to their messages. It cannot be too heavily stressed the prime importance of despatching a preliminary report to Lloyd's Agents within 24 hours of the first visit and thereafter keeping them up-to-date as work progresses. Underwriters require this information to set aside sums of money to cover their liability. Lack of this knowledge can seriously involve insurers in either over or under commitments.

These replies should be confined to a brief description of the nature and alleged cause of the damage so that underwriters may be informed of what is involved in the casualty. After this information has been given the extent of the damage should be outlined for guidance purposes only.

In the case of shell plating damages it is not necessary in the preliminary report to identify the precise location and degree of damage to each plate but the general area of the damage should be stated (e.g. starboard side forward) and the number of plates in each of the damage categories, namely:

(1) Those which require to be renewed.
(2) Those which require to be faired in place.
(3) Those which require to be cropped and part renewed.
(4) Those which require to be removed, faired and refitted.

In machinery damage it should be ensured that adequate information to enable Salvage to identify the damaged component is given. The use of the terms 'machinery breakdown' or 'electrical breakdown' should not be used although it is appreciated that detailed information may not be available initially. Salvage would, however, welcome advices indicating the immediate position, followed by more detailed information when it becomes available. This latter point is stressed and applies in every case, whether it relates to a new casualty or to the survey of a damage sustained at an earlier date. In all cases of damage surveyed, a message in cablegram form should be handed immediately to the Lloyd's Agent after the preliminary survey giving such information as is available at that stage and this should be followed by subsequent cables until all the required information has been provided.

5 UNITED STATES SALVAGE SURVEY INSTRUCTIONS

U.S. Salvage instructions for the survey of damage on vessels, will be received through the local Lloyd's Agents or direct from U.S. Salvage Association. These instructions will define particulars as to what has to be surveyed, where, when and for what purpose.

6 PARTICULAR ASPECTS OF DAMAGE REPAIRS

6.1 Painting

Where the structure of a ship has been repaired it is customary to apply priming coats of paint to new and disturbed parts. Underwriters traditionally accept the cost of the preparation of bare metal surfaces and the prime coating only in way of damages below the light load line, outside the hull. They also accept the cost of the preparation of bare metal surfaces and the complete painting or coating, in way of damages, above the light load line outside the hull. The recoating, as original, of all internal surfaces is accepted also.

'Priming' includes one coat of red lead, or zinc chromate, or other such prime coatings, but does not include anti-corrosive or anti-fouling paint or coatings; pickling, shot or sandblasting, etc., to remove mill scale may be accepted.

With regard to bottom painting, the Surveyor is sometimes asked to approve the full painting of the vessel. By this, it is meant the recoating such as is normally and periodically done. Such approval should never be given. If the owners insist on the inclusion of this painting, the Surveyor should always separate the cost from the repair account but include it in his report with the remark that this item is noted entirely without prejudice. Insofar as the Surveyor is concerned, he should assume that painting is never recoverable. If it should be, it is not in the Surveyor's power to say so and the item will be dealt with by the average adjuster.

When a vessel has been specially coated on the outside of the hull, below the light load line, say with hot or cold plastic, or with some other coating requiring special application processes, and where repairs have been made in way of such a coating and the affected area is to be recoated, it is necessary for the survey report to incorporate a breakdown as follows:

(1) The cost of the surface preparation for the coating.
(2) The cost of labour and material (agreed or estimated) involved in applying the first finished coat (including 'curing' coat if required).
(3) Any extra drydocking and cost of same required specifically for the preparation and application of the first coat.
(4) If further drydocking is required for successive coats, the time and cost of same.
(5) The labour and material costs in applying successive coats.

6.2 Deferred repairs

Frequently a Surveyor notes damage, repairs to which are to be deferred. In such cases, it should be stated in the report the reason why the repairs are being deferred and whether an Interim Certificate of Class is being issued. The report should contain enough detail to enable another Surveyor to visualise the repairs required and assess the value. Whilst acting on behalf of Salvage, it is the duty of the Surveyor to locate and describe clearly all damages. It is not sufficient to indicate that a plate is indented. The indent should be located precisely, e.g. between certain frames, and so many inches from the upper or lower seam of the plate together with the extent and maximum depth of indentation.

Damage reports detailing repairs to be deferred must contain dimensions of steelwork and clear identification of the affected parts. For example, when shell plates are numbered, it should always be made clear whether the numbering is from aft or forward, the same of course applies to frames, floors, or any other part about which confusion may arise. The reason for this identification is that the vessel may sustain

further damage in the same area at a later date. The estimated cost of repairs deferred is not to be included in the damage report but set out in a separate letter or memorandum.

Where repairs are deferred it is obvious that at the survey during which repairs are to be made, it will be necessary to establish whether or not the original damage has been aggravated, and certainly this cannot be done unless firstly, the damage can be located, and secondly, the damage is concisely described. Unless the damage is specifically located and described as above no proper price estimate of repairs can be made, and a repair contractor cannot be guided properly. The Surveyor should be careful to avoid certain wording, if unwarranted, in the damage findings. For example, the Surveyor should not use the words 'tailshaft subjected to shock', if only minor damage to a propeller is evident, for this implies that the shaft did indeed experience a blow. This would indicate that in any future failure of the shaft in question (regardless of whether or not at the initial survey the shaft was found damaged) the 'shock' as initially reported caused the damage ultimately found.

The Surveyor should prepare his own estimate of costs at the rates prevailing at the place of survey. A Surveyor may be called upon to survey damage, repairs to which had been previously deferred and are now to be carried out. In such cases it is usual for the Surveyor to be furnished with a copy of the report of the previous survey and he should ensure that the repairs recommended therein are not exceeded or, if they are, give reasons for extension of the recommendations. Advices regarding such extensions should be given to Lloyd's Agents immediately. In dealing with such deferred repair cases the Surveyor should ensure that only the repairs necessary to replace the structure in the same condition as before the damage was sustained are carried out. It often happens that due to lack of access or time, a deferred repair report contains recommendations in broad terms only and the second Surveyor, having the advantage of closer inspection may be able to recommend a modification which would satisfy classification requirements and owner's representatives. Thus a Surveyor is not bound to accept what a previous Surveyor has recommended where less will satisfy all requirements.

It sometimes happens that owners, for their own purposes, desire to defer permanent repairs and carry out temporary repairs which in all cases must be reported separately with full details of extent and cost. When permanent repairs are effected to the damage which had been temporarily repaired previously then the costs involved in removing the temporary repairs should be shown separately together with the time taken.

If a vessel sustained shell plate damage which did not in the least affect seaworthiness and if that vessel was in a port where repairs were known to be costly, the course proposed should be to defer repairs for attention at a less expensive port. It should be remembered that, if underwriters do become liable for repairs to a vessel, that liability is for the 'reasonable' cost of repairs.

The Surveyor has no authority to prevent an owner repairing his vessel, but he can and should report upon what is reasonable.

6.3 Temporary repairs

If an owner, for his own purposes, wishes to defer permanent repairs to another port and effect temporary repairs as necessary, underwriters would not be liable for the costs of these temporary repairs. However, if a vessel is at a port where only temporary repairs can be carried out, or, where it is considered it would be uneconomical to carry out permanent repairs the underwriters may be liable for the reasonable cost of these temporary repairs.

6.4 Estimated costs

In almost every case the Surveyor will be requested to estimate the cost of repairs. Fortunately, the usual damage sustained by vessels can be dealt with by itemised costs with which the Surveyors will be furnished.

Outport offices of the Society, where Surveyors act on behalf of Salvage, possess schedules of prices currently in use by ship repair yards in their district. Thus, if the unit rate is known to the Surveyor, the cost of the work may be calculated easily. The unit rates are to be regarded as maximum. The rates for drydock rent, based on gross tonnage of the vessel, will also be supplied so that dock hire charges can be assessed.

Difficulties may arise in costing items to which no schedule can be applied and the guiding principle must then be the number of man days considered necessary and the rate per day per man.

As regards materials, these can only be assessed in the light of ruling costs at each port and the Surveyors are recommended to record the costs of same, such as steel, timber, white metal, etc., so that it becomes a question of assessing only what quantity of material is necessary for any given job.

In an average repair involving steelwork, the ratio of labour to material is about 60/40, but obviously this cannot be applied generally, e.g. the cost of drawing a tailshaft would be almost entirely labour, whereas, in renewing the saloon mirror the cost will be largely one of material.

Where overtime is worked on any claim, the cost must be shown separately in respect of each claim. This applies to work done by tender or work done on a labour and material basis.

6.5 Tenders for damage repairs

In the 'Tender Clause' in a Marine Policy, provision is made for notice of any accident to be given to underwriters. The underwriters are given the right to decide to which port a vessel will be sent for repair and also the right, if necessary, to veto any particular place of repair, or repairing company, to which the owner intends sending his ship. The clause also provide that, in certain cases, the underwriters may request the owner to call for tenders for the repair of the damage sustained.

Usually, the shipowner advises his underwriters of his decision, to which he is entitled, to repair his ship at a certain port and by a named repairer. He can, however, simply advise his underwriters that his ship is at a certain port in need of repair, and ask for underwriters' instructions. In this case the underwriters may suggest the appointment of a Surveyor, and give instructions for tenders for the repairs to be obtained after a specification of the damages has been prepared, or they may suggest that the ship or vessel be sent to another port for survey.

Any expense to the owners, caused by the underwriters moving his ship for repairs, would be refunded by the underwriters, also a sum representing time lost may be claimed from underwriters whilst tenders are being obtained and considered.

6 . 6 **Repairs effected prior to survey**

If repairs have been effected to damage, but the actual damage has not been sighted by the Surveyor, then the Surveyor should obtain relevant information available, examine the completed repairs if possible, and include in his report all the facts and circumstances in narrative form.

6 . 7 **Schedules of prices**

The unit rates quoted in price schedules serve as guidance and reference for invoicing. The prices quoted are valid only when repairs are carried out within the premises of the repair company and will be increased as necessary when repairs are effected elsewhere.

The schedules issued by repairers cover typical repairs to steelwork and machinery together with costs for drydock rent, pipework, labour rates, rivetting and welding, cleaning, water testing and cementing of tanks, sandblasting, chipping and scraping, painting and bottom painting, carpentry work and general services.

The prices contained in schedules are subject to change according to fluctuation of wages or awards to workers and also to variations in material costs.

As the unit prices in schedules cover the cost of normal repairs to ships, the repairers will in most cases consider the granting of special rates for extensive repairs according to circumstances and the magnitude of the work involved.

It should be noted that schedules vary in their structure from yard to yard, some being more detailed than others, but usually they will contain most of the information to enable an approximation of cost to be made, viz.:

STEELWORK RATES, ETC.

ITEM	COST IN LOCAL CURRENCY / KG.
Shell plates, clear of tanks, cofferdams and peaks	
Renew	....
Off, fair and refit	....
Shell plates in way of tanks, cofferdams and peaks	
Renew	....
Off, fair and refit	....
Bilge strake plates	
Renew	....
Off, fair and refit	....
Flat keel plates	
Renew	....
Off, fair and refit	....
Shaped plates, such as forefoot plates, radiused stem plates, coffin plates, oxter plates requiring heat shaping	
Renew	....
Off, fair and refit	....
Tank top plates	
Renew	....
Off, fair and refit	....
Lift and relay tanktop or bilge ceiling, say 280 mm × 60 mm	
Per metre	....
Lift old and renew tanktop or bilge ceiling, say 280 mm × 60 mm	
Per metre	....
Remove and refit spar ceiling (say 150 mm × 50 mm	
Per metre	....
Renew spar ceiling as above	
Per metre	....
Remove and refit pipe or valve rod casings, three sides, each side, say 300 mm × 30 mm	
Per metre	....
Renew pipe or valve rod casings as above	
Per metre	....
Lift wood deck and renew, completely secured, caulked and dowelled, say 125 mm × 60 mm	
Per metre	....

ITEM	COST IN LOCAL CURRENCY/KG.
Lift and renew wood margins, completely secured, caulked and dowelled, say 230 mm × 60 mm	
Per metre	....
Renew rivets per 100	
below $\frac{3}{4}$ in dia.	....
$\frac{3}{4}$ in dia. and above	....
Stem bar and stern frame rivets	
Renew each	....
Caulk or set up rivets per 100	....
Weld rivets per 100	....
Caulk seams, butts	
Per metre	....
Weld seams, butts	
Per metre	....
Clean water ballast tanks, deep tanks and peaks	
Per ton capacity	....
Clean oil fuel D.B. tanks, deep or bunker tanks, cofferdams or peaks	
Per ton capacity	....
Caulk and paye wood decks	
Per 10 metres	....
Remove and replace keel blocks for access to repairs	
Per block	....

The above listed details are but a few of those one will find in the repairers' schedules.

A good schedule of prices will also include unit prices for disconnecting and lifting rudders for survey and replacing and reconnecting rudder pintle repairs or renewals, ranging anchors and cables in drydock and restowing using ship's windlass, labour rates for machinists, fitters and other trades and rates for the supply of electric current, circulating water, steam for heating purposes, fire watchmen's services and removal of garbage, etc.

The machinery schedule includes charges for the opening up of main and auxiliary engines, boilers, air, circulating, feed, bilge and sanitary pumps, condensers, the disconnecting of propellers, drawing in and cleaning tailshaft, including removal of adjacent shaft for access, opening out sea inlet cocks and valves, boiler and evaporator blow down cocks, steam windlass and steering engine, etc. The prices quoted for opening up or disconnecting any item do not include repairs or replacements. All removals for access to repairs and refitting same are chargeable and great care should be taken to include in the estimate all such items.

7 THE SURVEY REPORT

7.1 General

Damage surveys are physical surveys of a vessel or structure, the object of the survey being to establish:

(1) The cause of the damage.

(2) The extent of the damage.

(3) The recommended method of repair.

(4) The agreed or estimated cost.

In order to guide the underwriter in his decision as to whether or not a claim falls within the scope of his liability and to assist the claim adjuster to apportion costs, it is of the utmost importance that the cause of damage alleged be set down in detail.

In considering the cause of damage an examination of the log books should be made, not only in relation to a specific claim made by the owners, but also to make an assessment of the history of the vessel. It is customary in this respect to make an examination of the log books since the last drydocking. This examination may not always be conclusive, but usually the records earlier than the last drydocking are not available on board. Where a specific reference is required it may be made by the average adjuster's consulting engineer and the Surveyor may be requested to express his opinion on any relevant matter. When the opinion of the Surveyor is sought, all substantiated evidence will be provided for his consideration. The necessity for this close attention to the cause of damage may be illustrated:

An owner may claim for damage on the bottom of a vessel alleged due to pounding; an examination of the log books may reveal that prior to the alleged heavy weather the vessel had been aground in a manner which could have caused damage equally with heavy weather; possibly such damage may have been more likely due to the grounding. In such a case it may happen that the vessel was not insured at the time of the grounding or that, if insured, the risk was carried by underwriters other than those insuring the ship at the time of the heavy weather. This example will serve to show that, if liability exists, it should fall where it belongs.

Pursuing this example, the Surveyor, when dealing with London Salvage, should always state his opinion as to the likelihood of damage. The expression 'stated cause' of damage can lead to uncertainty as to whether the Surveyor concurs

in the stated cause or alternatively, in the absence of comment, the Surveyor may be considered to have concurred in the 'stated cause'.

The Surveyor should never report that a damage was due to an accident, but that he surveyed the vessel for damage 'alleged' to be the consequence of a certain incident and, if he is not in agreement that the defects found were consistent with the alleged causes, he should state so in his report.

If the Surveyor has not been able to examine the log books he should also state this in his report, and this will direct those concerned to make such a scrutiny. Whenever possible, however, the Surveyor should request to see and examine the log books back to the last drydocking and state in the damage report over what period the logs have been examined.

In certain cases claims may be made based upon an alleged accident, whereas examination of the facts in the light of the Surveyor's technical knowledge may show that the defects claimed are in fact wear and tear.

There is a wide field in which claims can be made and the Surveyor should at all times furnish the fullest information as to any claim made. It is no part of a Surveyors duty to interpret or apply the conditions contained in any policy and he should never attempt to do so, nor should he discuss same. Because of its importance the point is again mentioned that the Surveyor is never to report that anything claimed is 'underwriter's liability'.

The Surveyor, when attending on board a classed vessel to survey damage for maintenance of class and for salvage interests, will require to report to the Society only items of class damaged and the recommendations for repair whilst at the same time report to Salvage <u>all</u> damaged items claimed and the repair recommendations.

For Salvage, the Surveyor will require to investigate the prime cause of damage, state whether or not the damage found is consistent with the cause alleged, make detailed notes of all removals necessary to effect repairs (for costing), take note of capacities of tanks in way of damage (for costing), and note of dates of the vessel's arrival and departure from the repair area, commencement and completion of repairs, docking and undocking, etc.

Very frequently the Surveyor is requested to recommend repairs to different casualties and these should be kept separate in the survey report for London Salvage. For U.S. Salvage separate damage reports will require to be written for each casualty.

Drydock rent, where incurred, should always be kept separate and shown in full. The Surveyor should never attempt to apportion the cost of drydock dues as between various claims, but state which of the claims required drydock facilities to effect damage repairs and advise how long, in his opinion, repairs would have taken for each claim had each been effected alone.

When double bottom tanks and deep tanks used for oil fuel, and oil fuel bunkers and cargo oil tanks require to be cleaned for damage repairs, the cost for the work carried out and the cost of providing gas free certificates require to be shown in the damage report separately. If at all possible, the date(s) when last cleaned should also be stated.

During the course of repairs there are usually a number of items which are necessary services such as the supply of electric power and light, steam, fresh water for drinking, circulating water for the ship's refrigerating system, fire lines, garbage disposal, etc. These services also must be shown separately in the damage report together with respective costs, as they may be subject to apportionment in a similar manner to drydock dues.

In cases where there are a number of claims involving certain common items (say, for example, a grounding damage and heavy weather damage, both of which require the cleaning of a double bottom tank to effect repairs), the Surveyor, when examining accounts for approval, should make sure firstly, that separate accounts are submitted for each claim and secondly, that where a proportion of cost is arranged for common items that item is marked 'proportion' after a fair division has been agreed to between the owner's representative and the Surveyor.

It should be noted that when damage repairs have been effected to the satisfaction of the Surveyor a copy of the repairer's account should be obtained to ensure that all items stated in the Surveyor's damage report are reconcilable with those indicated in the ship's repair account before it is submitted to Lloyd's Agents for transmission to underwriters. If accounts have not been submitted before the issue of the damage report then reference to the unavailability of accounts should be indicated in the damage report.

When dealing with parts renewed because of damage, e.g. chain cable, propeller, tailshaft, etc., the report should state whether the cost of these new parts has been included or whether separate accounts will be submitted. When, for example, spare parts taken from ship's stores are used to replace those damaged, then the report should include a list of parts used and a statement to the effect that the owners will present separate accounts detailing costs.

An allowance for old tailshafts, propellers and steel should be given and the report should include reference as to whether or not credit has been allowed and if so, the amount. If, however, damage repairs have been put out to tender, the old material normally becomes the property of the repairers and no credit would be allowed.

7.2 The survey report (London Salvage)

The following phraseology should be used in the preamble to the survey report for London Salvage: ". . . for the purpose of ascertaining the cause, nature and extent of damage stated to have been sustained . . ." (*see* Appendices).

In the latter part of the report the Surveyor should then set forth his opinion as to whether or not the damage is consistent with, or is reasonably attributable to the alleged cause. If no allegation of the cause of damage is made by the owner's representative, the following phraseology may be used: "No allegation of cause has been made in respect of this damage. It is understood that if a claim is to be made the owner will notify his brokers of the allegation of cause. In view of the foregoing the defects now found and reported upon are noted without prejudice to liability and the owner's representative has been so informed."

When no allegation of the cause of damage is made, the Surveyor should make no reference in his report as to his opinion of the cause of damage, but give his reasons for the opinion formed in a separate memorandum or letter.

It should be specially noted that London Salvage do not now require the physical findings of damage to be listed in the damage report as 'Found' and 'Recommended' and in this respect the method embodied in the examples of London Salvage Damage Reports shown in the Appendix should be followed.

It should be borne in mind that the damage report detailing deferred repairs is normally used as a specification for repairs and it is imperative that the recommendations are fully detailed.

Damage repair accounts should be checked with the owner's representative and not with the shiprepairers unless the consent of the owner's representative has been obtained. When damage repair accounts require the Surveyor's signature, the accounts should be marked 'Damage Account' and signed 'Approved subject to and without prejudice to underwriters liability' and dated as necessary.

All Damage Reports for London Salvage Association require to be signed .... 'Surveyor for London Salvage Association'.

7.3 The survey report (United States Salvage)

When appointed by U.S. Salvage the Surveyor will receive the U.S. Salvage standard report forms, together with copies and memorandum forms with full instructions as to their proper usage. The U.S. Salvage report form includes a disclaimer clause and it is on this form only that all survey reports and preliminary advices are to be typed.

Each damage survey is issued with a case number by U.S. Salvage which should appear on the original and all copies of the survey report forms and memoranda. This case number is placed at the upper left hand corner of the first and each succeeding page. Each survey report is to be considered as an individual report and it is important to note that in the case of several damages on the same ship no more than one damage is to be included in any one report. In those cases where it is found there is no evident damage, one or more alleged casualties on the same vessel may be covered in one survey report. In a 'no claim' survey situation, i.e. where damage is found but the owner elects to make no claim on underwriters, the report can only cover one damage allegation.

The survey report form will require to contain the heading, sub-headings and the preamble which will indicate:

(1) the date of the survey,
(2) who requested the survey,
(3) what was surveyed,
(4) the owner of the property surveyed,
(5) where the survey was held, and
(6) the reason for the survey.

All individual dates of survey on which time was spent outside the Surveyor's office (including attendance at conferences elsewhere) should be listed in the preamble of the report. The use of the first date of attendance and the word 'subsequently' is not acceptable in U.S. Salvage reports.

U.S. Salvage state that visits of Surveyors are required only as is necessary to examine and determine the extent and cause of damage, agree on recommended repairs, verify that repairs have been completed, and agree to cost of repairs applicable. It is further stated that visits throughout the repair period for progress, testing and supervision are not the duty of their surveyors. Generally, one visit is required for deferred repair accidents, otherwise about three visits on damages where repairs are carried out; very few cases should require numerous visits.

In the preamble of the U.S. Salvage damage report it must be made clear that all facets of the survey are agreed to, except as noted. This is accomplished by including in the preamble of damage surveys the words ". . . in order to ascertain and agree upon or as noted otherwise, the cause, the nature and extent, and the recommended repair, of damage alleged to have been sustained in consequence of . . .'. The foregoing clearly indicates that agreement on any facet of the survey is implied by omission of expressed exception, and *vice versa*. If exception as to the cause of damage is not set forth, the survey report clearly indicates agreement as to the cause of the damage.

An exception to the cause of a damage is to be set forth in the report proper and in this instance the survey report will contain under the heading of 'Surveyor's Notes' the following statement of exception: "It is the opinion of the undersigned that the damage enumerated in the foregoing survey report (under items No. ....) would not be reasonably attributable to the alleged cause as set forth in the preamble and the owner's representative was so informed". The reasoning of the Surveyor for taking the exception is to be set forth on a separate memorandum which covers no other subject.

Immediately following the preamble the U.S. Salvage require a brief description of the vessel or structure under survey and a list of all those at interest attending the survey, such as owner's personnel, classification personnel, contractor's personnel, etc.

The log extracts (deck or engine room) are to be included in the survey report under the heading of 'Abstract of Deck (or Engine Room) Log'. Also included in this part of the report would be Letter(s) of Protest, etc., as presented by the owner or assured, as information pertinent to the case. In collision damage reports, log extracts or statements made available should not be included in the survey report but, if obtained, should be typed on a separate sheet and attached to the back of the survey report. Log extracts, Letters of Protest, etc., should be copied verbatim, including any grammatical, spelling, or other errors, and where such errors exist, the words "The foregoing is a true copy of the (deck/engine room) log (Protest), etc." should follow the statement. Searching of logs is only to be made at the request of, and as assistance to, the owner or assured.

Damage surveys require that the damage found and recommended method of repair be listed as 'Found' and 'Recommended' respectively, and so arranged in the report. Thereafter, cost information is presented and embodied in the report provided prices are agreed. Where estimates are made by the Surveyor, these estimates must not appear in the damage report but in a separate memorandum attached to the survey report.

Should the Surveyor be required to submit information of a confidential nature to U.S. Salvage this must be set forth on separate memoranda. However, information of this nature should always be forwarded to the Society's Head Office for approval before being sent to anyone outside the Society. If this is not done it can be a source of possible embarrassment to the Society. Extreme care is necessary when cases of a confidential nature arise.

As indicated previously, the Surveyor has no authority to order or contract for repairs, and if his report is intended for underwriters it must be concluded with a phrase indicating that the report is subject to adjustment and the survey made without prejudice.

It is the Surveyor's basic responsibility to arrive at a fair and reasonable cost for damage repairs and this function can be carried out by reviewing repair prices or *pro-forma* repair accounts before or after repairs have been effected. However, the Surveyor is prohibited from reviewing any repair account as a final approval action in connection with

the processing of the owner's claim and the function of stamping, signing, or in any way marking completed accounts for final approval for adjusting purposes is performed exclusively by the Executive Officer of U.S. Salvage Association in New York.

Surveyor's fees and expenses are not to be shown in the damage report but in a separate invoice which should be forwarded with the report. The invoice should show the fees and expenses separately.

Supplementary survey reports should have the words 'First Supplementary', 'Second Supplementary', etc., as the case may be, in the preamble of the report and a statement of reference to the original report or reports of survey (giving port of survey, date and case number of previous report(s) if available) should be included in the supplementary survey report after the notation of Surveyors attending the survey.

It should be noted when U.S. Salvage stationary is being used that the survey report forms and memoranda require a margin of one inch to be left at each side of the paper.

7.4 Field survey report (United States Salvage)

The U.S. Salvage Association requires that a field survey report be prepared at the actual time of the survey of each separate accident and forwarded, if possible, prior to the commencement of repairs, with preliminary advices. Should this not be possible then the field survey report should be forwarded simply as soon as possible.

This report details the facts and agreement reached by those attending the survey. The report contains a preamble, a 'Found' column listing all damages, a 'Recommended' column listing the repairs recommended, all necessary notes and additional recommendations pertinent to the damage repairs and repair costs, all of which should be worded in the same manner as would be required in the final survey report.

The Surveyor should note that the field survey report is considered to be a very important document in that it is a detailed specification and contract which sets forth the work to be carried out by a repair contractor and the agreed cost of same. It is binding on all parties signing it, including the contractor who agrees to effect the repairs at the agreed cost, all as described in the report.

If repairs have already been carried out prior to the survey, then a field survey report will not be required.

According to the U.S. Salvage Association it is the responsibility of their Surveyor to write the field survey report irrespective of whoever else volunteers to write it. This is not to infer that the Surveyor must write the field survey report but rather to indicate that finally, the responsibility rests with the Surveyor. The Surveyor therefore should not sign any field survey report unless he is satisfied with its contents, and in any case, a phrase indicating that the survey was made without prejudice should always appear above his signature. The Surveyor should sign all reports '.............. Surveyor for United States Salvage Association Inc.'.

Should repair costs not be negotiated or agreed at the survey, e.g. when repairs are deferred, the survey report will state that repairs are deferred and cost information will be omitted.

8 GENERAL DUTIES OF THE SURVEYOR

It must be repeated that the Surveyor has no authority to put in hand any work and therefore has no authority to agree to the cost of such work. Before proceeding to carry out a damage survey the Surveyor must obtain the consent of the owner's representative.

The Surveyor may recommend or approve the repairs (except when acting without prejudice as stated) if satisfied with the propriety of what is being done, and may approve the costs if it is agreed that they are fair and reasonable. If he is not satisfied with what is being done, it should be stated so in the report.

It should be noted that it is the owner's representative's responsibility to provide all information relevant to the casualty for which damage repairs are being claimed and to make allegations as to the cause of damage.

The Surveyor will normally be instructed by the local Lloyd's Agent and he will therefore furnish all advices and reports to these agents who, in turn, will transmit the information to Salvage Association in London or U.S. Salvage in New York.

Cases have occurred where average adjusters have written directly to the Surveyors for information concerning a survey report. This is undesirable and the Surveyor should not reply direct to any such communication but should furnish the local Lloyd's Agent with a copy of such a letter, together with his reply, the latter being addressed to the Secretary of the respective Salvage Association and the Lloyd's Agent will forward all correspondence to that office where the facts will be considered. This is a most important point and no deviation is permitted except on specific instruction from the Secretaries concerned. Careful note should be taken of what has already been stated regarding the submission of information of a confidential nature.

It may happen that during the examination of a vessel or consideration of a claim, the Surveyor becomes aware of conditions which may be unfavourable to an underwriter's interest, then his duty would be to write a confidential letter to the Lloyd's Agent who would, in turn, transmit it in confidence to Salvage.

Surveyors, whilst acting on behalf of underwriters, are not permitted to certify a ship or vessel as being seaworthy. If, however, the Surveyor observes that a vessel is not fit to proceed to sea and constitutes a bad risk, he should notify Lloyd's Agents and further, if the vessel in question is classed with the Society, he is duty bound to notify Headquarters in London by cable.

For example, a dry cargo vessel, classed with the Society and fully laden, sustains underwater damage alleged by grounding causing flooding of forward compartments and double bottom tanks and serious damage to main internal structure, arrives at a port, where facilities for both repair and discharge of cargo are non-existent. If it is evident that the integrity of the main structure has been impaired to such a degree that an assessment of the strength of the damaged areas is required before proceeding on voyage, it is imperative that all relevant information regarding the nature and extent of damage, type and distribution of cargo, extent of flooding and draughts fore and aft, etc., be transmitted immediately to Headquarters for investigation. After assessment of structural strength of the damaged areas has been carried out, it may be that the vessel is not considered fit to proceed to sea or continue its voyage without repair and the Surveyor would be advised accordingly.

The Surveyor attending should not issue an Interim Certificate of Class in this case but should issue a factual report of damage found to Salvage and forward a usual Report 8 to L.R. London.

A note here on average adjusters may be opportune. The average adjuster is highly skilled and specialises in the interpretation of marine insurance policies and the presentation of claims whilst acting as an independent authority. He usually has considerable technical knowledge but, where advice on technical points is required, he makes use of consulting engineers and marine surveyors. It will be seen that, in the interpretation or presentation of any claim, the adjuster relies on technical advice to some extent and the Surveyor is expected to furnish a report with all relevant details which will be of use to the underwriters in his negotiations with the adjuster. By incorporating this necessary information in his report, the Surveyor may avoid considerable correspondence which may come at a time when the details of a case are no longer fresh in his mind.

9 CONCLUSION

An attempt has been made in this paper to give an indication of the salient features of damage report writing and the duties of the Surveyor whilst surveying damage on behalf of Salvage. The Author does not, however, claim to have covered all aspects but hopes this article serves to fulfil the purpose for which it was written and focus attention on this interesting and absorbing subject.

ACKNOWLEDGEMENTS

The Author wishes to express gratitude to Mr. J. R. Lindgren, ex-President of the United States Salvage Association Inc., New York, for permission to incorporate in this paper salient features of the 'Marine Surveying Manual' and also to express appreciation of the advice and assistance given by Mr. J. W. Weir and Mr. C. A. Sinclair of the London Salvage Association.

REFERENCES

1. *Marine Insurance Act,* 1906
2. *York Antwerp Rules,* 1924
3. *Instructions to Surveyors*—Part 5, 1967 (Section 1) Damage Surveys (Hull and Machinery)

BIBLIOGRAPHY

1. Templeman and Greenacre, *Marine Insurance—its Principles and practice.* MacDonald and Evans 1970 (fourth edition).

APPENDIX 1

London Salvage damage report (accounts available).

LLOYD'S REGISTER OF SHIPPING

71, Fenchurch Street, London, EC3M 4BS

Report No. OO.
Bilbao, Spain.
20th January, 1973.

THIS IS TO CERTIFY THAT at the request of Messrs. ...., Lloyd's Agents, on behalf of The Salvage Association, London, and with the consent of the Owner's Representative, the undersigned Surveyor attended onboard the single screw motor vessel

"SAMPLE"

of the port of Monrovia, 30000 tons gross, whilst lying in drydock at Bilbao, Spain, for the purpose of ascertaining the cause, nature and extent of damage stated to have been sustained in the following circumstances:-

FIRST. 16.9.1972. - CONTACT BERTHING AT KANDERA, INDIA.

Whilst berthing at Kandera, India the vessel contacted Pier No. 40, sustaining damage to starboard side shell plating aft in way of oil fuel bunker at forward end of Engine Room.

SECOND. 17.12.1972. - STRANDING IN DELAWARE RIVER, PA, U.S.A.

Whilst proceeding down the Delaware River the vessel grounded and lay stranded at 1903 hours, refloating at 2218 hours the same day using the main engines and assisted by Tug "Henry Moran".

For further particulars please refer to the vessel's log books, which have not been sighted. The above is based on the Master's report of the incidents.

8th January, 1973.

Proceeded to the vessel on this and subsequent dates in company with the Owner's Representative and found and recommended as follows:

This Certificate is issued upon the terms of the Rules and Regulations of the Society, which provide that:—

"The Committees of the Society use their best endeavours to ensure that the functions of the Society are properly executed, but it is to be understood that neither the Society nor any Member of any of its Committees nor any of its Officers, Servants or Surveyors is under any circumstances whatever to be held responsible or liable for any inaccuracy in any report or certificate issued by the Society or its Surveyors, or in any entry in the Register Book or other publication of the Society, or for any act or omission, default or negligence of any of its Committees or any Member thereof, or of the Surveyors, or other Officers, Servants or Agents of the Society".

N. (Rpt. 10c.—Lon.) 2m.10,71 (MADE AND PRINTED IN ENGLAND)

Also present at surveys:-

Owner's Representative . . . . Mr.
Classification Surveyor . . . . . . Mr.
Repairers' Representative . . . . . Mr.

FIRST. 16.9.1972. - CONTACT.

Heavy indentation of starboard side shell plating aft in way of oil fuel bunker at forward end of Engine Room was found, necessitating the renewal of one shell plate in each of 'J' and 'K' strakes, and the fairing in place of one shell plate in 'J' strake.

Distortion of internal structure in way of damaged shell plating found, necessitating the cropping and part renewing of five shell frames, one web frame, five beams, bulkhead and stringer plating and renewing beam knees.

In our opinion the damage found could reasonably be attributed to the alleged cause.

SECOND. 17.12.1972. - STRANDING.

Section 'A' - Stranding.

Heavy indentation of bottom shell plating in way of No. 1 Double Bottom Tank, port and starboard, was found, necessitating the renewal of two keel plates, two garboard strake plates, the part renewal of one garboard strake plate and the fairing in place of one "B" strake plate.

Distortion of internal structure in way of damaged bottom plating found, necessitating the cropping and part renewing of sixteen floors, fairing in place one floor, four side girders being cropped and part renewed, the cropping and part renewing of four shell longitudinals and fairing in place the centre girder.

In our opinion the damage found could reasonably be attributable to the alleged cause.

Section "B" - Efforts to refloat.

Main Condenser and Pump, and five sea valves found fouled necessitating opening up, cleaning, and reassembling.

In our opinion the damage found could reasonably be attributable to the alleged cause.

The foregoing damages were repaired by Nervion Shiprepairing Company, Bilbao, Spain, as per the attached accounts, which have been duly approved as being fair and reasonable, as requested by the Owners, subject to Underwriters' liability and adjustment in the usual manner, and to the following:-

-3-

Drydocking Account No. OOOO. dated 18th January, 1973, for Pesetas . . . . . .

Drydock Services Account No. OOOO. dated 18th January, 1973, for Pesetas . . . . . .

Riggers Services Account No. OOOO. dated 18th January, 1973, for Pesetas . . . . . .

Tugboat Services Account No. OOOO. dated 18th January, 1973, for Pesetas . . . . . .

The above accounts should require the attention of the Adjuster.

Casualty No. 1 - Contact Account No. OOOO dated 19th January, 1973, for Pesetas . . . . . .

Casualty No. 2 - Section "A" Stranding Account No. OOOO dated 19th January, 1973, for Pesetas . . . . . .

Casualty No. 2 - Section "B" Efforts to refloat Account No. OOOO dated 19th January, 1973, for Pesetas . . . . . .

NOTES:-

Casualty No.1.

Credit for the scrap value of the condemned steel material amounted to Pesetas . . . . . . as per attached credit note from Nervion Shiprepairing Company. This figure is considered fair and reasonable.

Casualty No. 2 - Section "A" Stranding.

Credit for the scrap value of the condemned steel material amounted to Pesetas . . . . . . as per attached credit note from Nervion Shiprepairing Company. This figure is considered fair and reasonable.

Repairs commenced - 8th January, 1973.
Vessel drydocked - 8th January, 1973.
Vessel undocked - 15th January, 1973.
Repairs completed - 15th January, 1973.
Vessel last drydocked - March, 1972.
Oil fuel bunker (s.s.a.) last cleaned - March, 1972.

The repairs were carried out concurrently with work to Owners' account, also requiring drydocking, but if the damage repairs had been effected alone, they would have required the

following periods to complete:-

FIRST
16.9.1972. - Contact - three days in drydock.

SECOND
17.12.1972. - Stranding:-

Section "A" - Eight days in drydock.

Section "B"
(a) Cleaning Main Condenser and Pump - Two days afloat.
(b) Cleaning five sea valves - Two days in drydock.

Owners repairs affecting seaworthiness - three days in drydock.

....
Surveyor for The Salvage
Association, London.

APPENDIX 2

London Salvage damage report (accounts not available).

LLOYD'S REGISTER OF SHIPPING

71, Fenchurch Street, London, EC3M 4BS

Report No. OO.
Bilbao, Spain.
January 20th 1973.

THIS IS TO CERTIFY THAT at the request of Messrs. --------------------Lloyd's Agents, on behalf of The Salvage Association, London, and with the consent of the Owner's Representative, the undersigned Surveyor attended onboard the single screw steel vessel

"SAMPLE"

of the port of Monrovia, 30000 tons gross, whilst lying in drydock at Bilbao, Spain, For the purpose of ascertaining the cause, nature and extent of damage alleged to have been sustained in the following circumstances:-

FIRST. 16.9.1972. - CONTACT BERTHING AT KANDERA, INDIA.

Whilst berthing at Kandera, India, the vessel contacted Pier No. 40, sustaining damage to starboard side shell plating aft in way of oil fuel bunker at forward end of Engine Room.

SECOND. 17.12.1972. - STRANDING IN DELAWARE RIVER, Pa, U.S.A.

Whilst proceeding down the Delaware River the vessel grounded and lay stranded at 1903 hours, refloating at 2218 hours the same day using the main engines and assisted by Tug "Henry Moran".

For further particulars, please refer to the vessel's log books, which have not been sighted. The above is based on the Master's report of the incidents.

8th January, 1973.

Proceeded to the vessel on this and subsequent dates in company with the Owners' Representative and Representatives of other interested parties, and found as follows:-

This Certificate is issued upon the terms of the Rules and Regulations of the Society, which provide that:—
"The Committees of the Society use their best endeavours to ensure that the functions of the Society are properly executed, but it is to be understood that neither the Society nor any Member of any of its Committees nor any of its Officers, Servants or Surveyors is under any circumstances whatever to be held responsible or liable for any inaccuracy in any report or certificate issued by the Society or its Surveyors, or in any entry in the Register Book or other publication of the Society, or for any act or omission, default or negligence of any of its Committees or any Member thereof, or of the Surveyors, or other Officers, Servants or Agents of the Society".

N. (Rpt. 10c.—Lon.) 2m.10,71 (MADE AND PRINTED IN ENGLAND)

FIRST. 16.9.1972. CONTACT

Shell Plating (s.s.a.) (plates numbered from aft)

No. 8 plate in 'J' and 'K' strakes heavily set in over full length and width and No. 9 plate in 'J' strake indented slightly in way of after butt.

Internals (s.s.a.) (frames numbered from aft)

Five in number main side frames and one plate web frame in way of damaged shell plates 'J' and 'K' set in and distorted.
Oil tight bulkhead wing plate at frame No. 60 buckled adjacent to set in shell plates.
'F' deck stringer plate in way of damaged shell plates and aft of frame No. 60 heavily buckled.
Five beams and beam knees in way of 'F' deck badly buckled.
End brackets of Flats Nos. 2 and 3 and 'F' deck stringer distorted.
In our opinion, the damage found could reasonably be attributable to the alleged cause.

SECOND. 17.12.1972. STRANDING

Bottom Shell Plating (p &sf) in way of No. 1 D.B. Tank.

(Plates numbered from aft.)

Keel plates FK-24 heavily indented for full length and FK-25 heavily indented for forward three-quarters length.
Port side A strake plates Nos. 24 & 25 heavily indented for full length and for after half length respectively. Strake B plate No. 24 moderately indented between floors for after half length in way of after seam.
Starboard side A strake plate No. 24 indented bodily for full length and A-25 slightly indented at after end.

Internals in way of above damaged shell plates.

Centre girder, side girders at 1400 mm and 2900 mm off centre line, port and starboard, and transverse floors moderately to heavily buckled at shell connections.
Two shell longitudinals, port and starboard, heavily buckled.
In our opinion, the damage found could reasonably be attributable to the alleged cause.

SECOND. 17.12.1972. EFFORTS TO REFLOAT

Main condenser, main condenser pump and five sea valves subjected to fouling.

In our opinion, the damage found could reasonably be attributable to the alleged cause.

The above damage repairs were carried out concurrently with work to Owner's account, also requiring drydocking, but if the damage repairs had been effected alone, they would have required the following periods to complete:-

FIRST
16.9.1972. - CONTACT - Three days in drydock.

SECOND.

17.12.1972. - STRANDING - Eight days in drydock.

- EFFORTS TO REFLOAT -

(a) Cleaning Main Condenser and Pump - Two days afloat.

(b) Cleaning five Sea Valves - Two days in drydock.

Owner's repairs affecting seaworthiness - Three days in drydock.

The Owners put the repairs in hand with Nervion Shiprepairing Company, Bilbao, Spain, and were carried out as per accounts, which to date have not been presented for our approval.

On receipt and approval of these accounts, an addendum to this report will be prepared and forwarded for attachment thereto.

Vessel arrived at Bilbao.	8th January, 1973.
Vessel entered drydock and repairs commenced.	8th January, 1973.
Vessel undocked and repairs completed.	15th January, 1973.
Vessel left Bilbao.	16th January, 1973.
Vessel Last drydocked	March, 1972.

Surveyor for The Salvage Association, London.

APPENDIX 3

Special addendum to London Salvage damage report (when accounts become available).

M. S. "SAMPLE".

Addendum to Survey Report No. 00. dated 20th January, 1973.

The following accounts have been agreed between the Owners and the Repairers with our approval being considered fair and reasonable, subject to Underwriters' liability and adjustment in the usual manner.

(1) Contact Damage Account No. 0000. dated 19th. January, 1973, for the sum of Pesetas..................

(2) Stranding Damage Account No. 0000. dated 19th. January, 1973, for the sum of Pesetas..................

(3) Stranding - "Efforts to Refloat" Damage Account No. 0000. dated 19th. January, 1973, for the sum of Pesetas..............

(4) Drydocking Account No. 0000. dated 18th. January, 1973, for the sum of Pesetas.................

(5) Drydock Services Account No. 0000. dated 18th. January, 1973, for the sum of Pesetas.......................

(6) Riggers Services Account No. 0000. dated 18th. January, 1973, for the sum of Pesetas.......................;

(7) Tugboat Services Account No. 0000. dated 18th. January, 1973, for the sum of Pesetas......................

(8) Contact Damage - Credit Note for the scrap value of the condemned steel material amounted to the sum of Pesetas.................

(9) Stranding Damage - Credit Note for the scrap value of the condemned steel material amounted to the sum of Pesetas..................

Copies of these accounts are forwarded for attachment to the Survey Report.

At this time no other average repairs were carried out.

Surveyor for The Salvage
Association, London

APPENDIX 4

United States Salvage damage report—contact damage.

FORM 147 E. F. & CO. LTD.

UNITED STATES SALVAGE ASSOCIATION, INC.

99 JOHN STREET NEW YORK 10038, N.Y.

CASE NO. 00-0000
Contacted Dock
September 16 1972

Bilbao Spain.
January 20, 1973

CONDITIONS

The employment of this Association and all services rendered in connection therewith are made, offered and rendered without recourse and on the following conditions and this and all other reports, including any oral reports and certificates, are made and issued without recourse and subject to said conditions:

1. While the officers and the Board of Directors of United States Salvage Association, Inc. have used their best endeavors to select competent surveyors, employees, representatives and agents and to insure that the functions of the Association are properly executed, neither the Association nor its officers, directors, surveyors, employees, representatives or agents are under any circumstances whatever to be held responsible for any error of judgment, default or negligence of the Association's surveyors, employees, representatives or agents nor shall the Association or its officers or directors under any circumstances whatever be held responsible for any inaccuracy, omission, misrepresentation or misstatement in any report or certificate.

2. That the information contained in this and all other reports and certificates is only that coming to the attention of or under the observation of such surveyors, employees, representatives and agents and deemed pertinent for the purpose for which the Association was employed as stated herein; that this report or certificate is not a Certificate of Seaworthiness; that under no circumstances shall this report or certificate be used in connection with the issuance, purchase, sale or pledge of any security or securities, or in connection with the purchase, sale or mortgage, pledge, freighting, letting, hiring or charter of any vessel, cargo or other property, and if so used shall be null, void and of no effect and shall not be binding on anyone.

3. Reports subject to these conditions are the only reports authorized by the Association.

4. The terms of these conditions can be varied only by specific resolution of the Board of Directors of the Association and the acceptance or use of this report or of the employment or services of this Association or of its surveyors, employees, representatives or agents or the use of any other report or certificate shall be construed to be an acceptance of these conditions.

5. This report and all services in connection with this employment are for the account of the person requesting the same, but with the understanding that they are to be used only for the purpose for which the Association was employed as stated herein.

M.S. "SAMPLE".

Report of survey made by the undersigned Representative of the United States Salvage Association, Inc., on January 8, 10 and 11, 1973, at the request of Smith & Jones Ltd., on the M.S. "SAMPLE", 30000 tons gross, 123456 Official Number, (Liberian Registry), Ship Cargo Inc., Owners Newship Corp. Operators whilst lying in drydock at the yard of Nervion Shiprepairing Co., Bilbao, Spain, in order to ascertain and agree upon or as noted otherwise, the cause the nature and extent, and the recommended repair of damage alleged to have been sustained in consequence of the vessel having contacted the dock wall during berthing operations at Pier 40 Kanders India, at 1430 hours, September 16 1972.

DESCRIPTION.

This vessel is one of the new motor container ships of this Owner's fleet built in 1968, with machinery aft and seven holds. All holds are designed and fitted for the stowage of containers. The vessel is equipped with diesel motor propulsion machinery of 28500 B.H.P.

ATTENDING.

Mr .... Representing Ship Cargo Inc..
Mr .... Representing ....
Mr .... Representing ....
Mr .... Representing Nervion Shiprepairers Co.

ABSTRACT OF DECK LOG.

September 16, 1972.

1200 - 1600:	1405 -	SBE, Pilot ....aboard.
	1410 -	Anchor aweigh.
	1414 -	Port fwd tug fast.
	1419 -	Port qtr. tug fast.
	1421 -	Half astern.
	1430 -	Contacted Pier 40 starboard side aft
	1438 -	FWE.

FOUND : RECOMMENDED

SHELL PLATING. :

STARBOARD SIDE AFT. :

(Plates numbered from aft as per shell expansion plan.)

"K" Strake. :

1.

FOUND	RECOMMENDED
1. Plate No. 8 heavily set in between frames No 54 to 60 to a maximum depth of 3" over full width.	To be renewed. Size:- 6.900M x 2.550M x 1.700M x 15.5m/m Tapered.
"J" Strake	
2. Plate No 8 heavily set in between frames No 54 to 60 to a maximum depth of 4" over full width	To be renewed Size:- 8.800M x 2.750M x 15.5m/m.
3. Plate No 9 indented slightly in way of after butt between frames No 60 & 61.	Plate to be released locally, heated and faired in place and resecured. Total area involved 2 sq Ms..

INTERNALS - STARBOARD SIDE AFT.

(Frames numbered from aft)	
4. Shell frames Nos. 54, 55, 57, 58 & 59 heavily buckled over an average length of 4.800M in way of Shell plates "K" 8 & "J"8	Five frames to be cropped and partly renewed. Size of renewed sections:- 5 x 2.5M x 12" x 45" OBP. 5 x 3.0M x 11" x 43" OBP.
5. Web frame No. 56 buckled heavily in way of damaged shell plates "K" 8 & "J"8 & face plate distorted.	To be cropped and partly renewed with part new face plate. Size of renewed sections:- 5.5M x .650M x 10.5m/m 6.25M x .150M x 12m/m F.B.
6. Oil tight bulkhead plating at frame No 60 buckled at wing adjacent to shell.	Bulkhead wing plate to be cropped and partly renewed Size of renewed section:- 4.0M x 850M x 10m/m.
7. "F" deck stringer plate buckled heavily between frame Nos. 53 & 61.	To be cropped and partly renewed. Size of renewed section:- 6.4M x 1.0M x 10m/m.
8. End bracket of Flat No.3 between frames Nos. 57-60: heavily buckled.	To be renewed. Size of renewed section:- 2.5M x 2.4M x 10m/m.
9. End bracket of Flat No.2 between frame Nos. 57-60 slightly set down and bent between frame Nos. 57 & 59.	Bracket to be released locally, heated and faired in place over an area of approximately 3 sq. metres and resecured.
10. "F" Deck beams at frames Nos. 54 55,57,58 & 59 badly distorted at ends and beam knees in way buckled.	Five beams to be cropped and partly renewed and five beam knees to be renewed. Size of renewed sections:- 2 @ 1.3M x 11" x 43" OBP 3 @ 1.3M x 9" x 42" OBP. 1 plate 3.0M x .550M x 11.5m/m.
11. "F" Deck end bracket between frames Nos. 61-63: slightly bent.	To be released locally, faired in place over an area of approx. 1 sq. metre and resecured.

NOTES.

A. Necessary drydocking to effect repairs.
B. Necessary tugs to assist vessel into and out of drydock.
C. Necessary Riggers to handle mooring lines and gangway.
D. Necessary removals to be replaced as originally
E. The following drydock services to be supplied , including connecting up and disconnection as applicable.

Fire line.
Circulating water for vessel's refrigerating system.
Electricity for lighting heating, cooking and other living purposes.
Fresh water for drinking and sanitary purposes.
Garbage removal.
Telephones.

F. Necessary staging to be erected inside and out and afterwards dismantled.
G. Necessary steaming and cleaning to gas free starboard side oil fuel bunker aft.
H. Necessary gas free certificate to be provided.
I. Necessary removal of debris from oil fuel bunker starboard side aft on completion of repairs.
J. All new and repaired work to be tested and proven tight.
K. All new and repaired work to be prime coated on external surfaces below light load line and recoated as originally elsewhere.
L. Value of scrap material from this repair to be credited.

The Nervion Shiprepairing Co., submitted a price in the amount of Pesetas ...., to effect the foregoing repairs, excluding Notes A.B.C.E. and H but reflecting a scrap credit of Pesetas .... This price is considered fair and reasonable

It was agreed that if carried out alone, the foregoing repairs would require

Drydocking - Note A:

One haul day at Pesetas	.......Pesetas
Two lay days at Pesetas	,.......Pesetas
Total	Pesetas
Tugboats Note B	Pesetas
Riggers Note C..........................	Pesetas
Drydock Services Note E.....	Pesetas
Gas Free Certificate Note H	Pesetas

Included in the cost to effect repairs are the following two items:

Cleaning of oil fuel bunker starboard side aft Note G..................	Pesetas
Removal of debris from oil fuel bunker starboard side aft..................	Pesetas

SURVEYOR'S NOTES.

The foregoing repairs were carried out concurrently with Owner's work and repairs of one other damage as described in the following Report:

CASE NO. 00-0000 - Stranding Damage - December 17, 1972.

Owner's work consisted of drydocking vessel for underwater examination, ranging of anchors and cables, examination of sea valves cleaning and painting the underwater body and minor repairs to bottom plating, all of which, if done alone would have required three days in drydock.

Date of last drydocking........................March 3, 1972.

Shirboard aft oil fuel bunker last cleaned....March, 1972.

Arrival of vessel at repair area..............2 A.M. 8-1-73.
In drydock....................................7 A.M. 8-1-73.
Completion of damage repairs..................9 P.M. 10-1-73.
Off Drydock...................................5 P.M. 15-1-73.
Departure of vessel from repair area..........11 A.M.16-1-73.

Surveyor for United States
Salvage Association Inc.

APPENDIX 5

United States Salvage field survey report—contact damage.

FIELD SURVEY REPORT

M.S. "SAMPLE" January 8, 1973.

We, the undersigned, have this day held survey on the M.S. "SAMPLE", 30000 tons gross 123456 Official Number, Ship Cargo Inc., Owners, Newship Corp., Operators, whilst lying in drydock at the yard of Nervion Shiprepairing Co., Bilbao, Spain, in order to ascertain and agree upon or as noted otherwise, the cause, the nature and extent, and the recommended repair, of damage alleged to have been sustained in consequence of the vessel having contacted the dock wall, during berthing operations at Pier 40, Kandera, India, at 1430 hours September 16 1972.

FOUND	RECOMMENDED
SHELL PLATING.	
STARBOARD SIDE AFT.	
(Plates numbered from aft as per shell expansion plan.)	
"K" Strake.	
1. Plate No. 8 heavily set in between frames Nos. 54 to 60 to a maximum depth of 3 " over full width.	1. To be renewed. Size:- 6.900M x 2.550M x 1.700M x 15.5m/m.
"J" Strake.	
2. Plate No. 8 heavily set in between frame Nos. 54 to 60 to a maximum depth of 4" over full width.	2. To be renewed. Size:- 8.800M x 2.750M x 15.5m/m.
3. Plate No. 9 indented slightly in way of after butt between frames Nos. 60 to 61.	3. Plate to be released locally, heated and faired in place and resecured. Total area involved 2 sq. Metres.
INTERNALS - STARBOARD SIDE AFT.	
(Frames numbered from aft.)	
4. Shell frames Nos. 54,55, 57, 58 & 59 heavily buckled over an average length of 4.800M in way of shell plates "K"8 & "J"8.	4. Five frames to be cropped and partly renewed. Size of renewed sections:- 5 x 2.5M x 12" x .45" OBP. 5 x 3.0M x 11" x .43" OBP.

FOUND	RECOMMENDED
5. Web frame No. 56 buckled heavily in way of damaged shell plates "K"8 & "J"8 & face plate distorted.	5. To be cropped and partly renewed with part new face plate. Size of renewed sections:- 5.5M x .650M x 10.5m/m. 6.25M x .150M x 12m/m F.B.
6. Oil tight bulkhead plating at frame No. 60 buckled at wing adjacent to shell.	6. Bulkhead wing plate to be cropped and partly renewed. Size of renewed section:- 4.0M x .850M x 10m/m.
7. "F" deck stringer plate buckled heavily between frame Nos. 53 & 61.	7. To be cropped and partly renewed. Size of renewed section: 6.4M x 1.0M x 10m/m.
8. End bracket of Flat No.3 between frames Nos. 57 & 60 heavily buckled.	8. To be renewed. Size of renewed section:- 2.5M x 2.4M x 10m/m.
9. End bracket of Flat No.2 between frame Nos. 57 & 60 slightly set down and bent between frame Nos. 57 & 59.	9. Bracket to be released locally, heated and faired in place over an area of approximately 3 sq. metres and resecured.
10. "F" Deck beams at frames Nos. 54 55,57,58 & 59 badly distorted at ends and beam knees in way buckled.	10. Five beams to be cropped and partly renewed and five beam knees to be renewed. Size of renewed sections:- 2 @ 1.3M x 11" x .43" OBP. 3 @ 1.3M x 9" x .42" OBP. 1 plate 3.0M x .550M x 11.5 m/m
11. "F" Deck end bracket between frames Nos. 61 & 63 slightly bent.	11. To be released locally, faired in place over an area of approximately 1 sq. metre and resecured.

NOTES.

A. Necessary drydocking to effect repairs,(1 haul and 2 lay days)
B. Necessary tug assistance into and out of drydock.
C. Necessary Riggers to handle mooring lines and gangway.
D. Necessary removals to be replaced as originally.
E. The following drydock services to be supplied, including connecting up disconnecting as applicable:-

Fire line.
Circulating water for vessel's refrigerating system.
Electricity for lighting, heating, cooking and other living purposes.
Fresh water for drinking and sanitary purposes.
Garbage removal.
Telephones.

F. Necessary staging to be erected inside and out and afterwards dismantled.
G. Necessary steaming and cleaning to gas free starboard side oil fuel bunker in way of damage.
H. Necessary gas free certificate to be provided.
I. Necessary removal of debris from starboard oil fuel bunker on completion of repairs.
J. All new and repaired work to be tested and proven tight.
K. All new and repaired work to be prime coated on external surfaces below light load line and recoated as originally elsewhere.
L. Value of scrap material from this repair to be credited.

The Nervion Shiprepairing Co. aggrees to effect the foregoing repairs for the sum of Pesetas............ exclusive of notes A,B,C, E and H, but reflecting a scrap credit of Pesetas.............
This price is considered fair and reasonable.

Survey made without prejudice.

(Signature) ....
Mr............Representing Ship Cargo Inc.

(Signature)................
Mr............Representing United States Salvage Assoc. Inc.

(Attended but did not sign)
Mr. .... Representing

(Signature)..................
Mr...........Representing The Nervion Shop-repairers Co.

APPENDIX 6

United States Salvage damage report—stranding damage.

FORM 147 E. F. & CO. LTD.

UNITED STATES SALVAGE ASSOCIATION, INC.

99 JOHN STREET NEW YORK 10038, N. Y.

SALVAGE · UNITED STATES · ASSOCIATION · INC 1921

CASE NO.

CASE NO. 00-0000 Bilbao, Spain
Stranding. January 20, 1973
December 17, 1972.

CONDITIONS

The employment of this Association and all services rendered in connection therewith are made, offered and rendered without recourse and on the following conditions and this and all other reports, including any oral reports and certificates, are made and issued without recourse and subject to said conditions:

1. While the officers and the Board of Directors of United States Salvage Association, Inc. have used their best endeavors to select competent surveyors, employees, representatives and agents and to insure that the functions of the Association are properly executed, neither the Association nor its officers, directors, surveyors, employees, representatives or agents are under any circumstances whatever to be held responsible for any error of judgment, default or negligence of the Association's surveyors, employees, representatives or agents nor shall the Association or its officers or directors under any circumstances whatever be held responsible for any inaccuracy, omission, misrepresentation or misstatement in any report or certificate.

2. That the information contained in this and all other reports and certificates is only that coming to the attention of or under the observation of such surveyors, employees, representatives and agents and deemed pertinent for the purpose for which the Association was employed as stated herein; that this report or certificate is not a Certificate of Seaworthiness; that under no circumstances shall this report or certificate be used in connection with the issuance, purchase, sale or pledge of any security or securities, or in connection with the purchase, sale or mortgage, pledge, freighting, letting, hiring or charter of any vessel, cargo or other property, and if so used shall be null, void and of no effect and shall not be binding on anyone.

3. Reports subject to these conditions are the only reports authorized by the Association.

4. The terms of these conditions can be varied only by specific resolution of the Board of Directors of the Association and the acceptance or use of this report or of the employment or services of this Association or of its surveyors, employees, representatives or agents or the use of any other report or certificate shall be construed to be an acceptance of these conditions.

5. This report and all services in connection with this employment are for the account of the person requesting the same, but with the understanding that they are to be used only for the purpose for which the Association was employed as stated herein.

M.S. "SAMPLE"

Report of survey made by the undersigned Representative of the United States Salvage Association, Inc., on January 8, 10, 12 and 15, 1973, at the request of A.B.C. Insurance Brokers Ltd., on the M. S. "SAMPLE", 30000 tons gross, 123456 Official Number, (Liberian Registry), Ship Cargo Inc.,`Owners, Newship Corp., Operators, whilst lying in drydock at the yard of Nervion Shiprepairing Co., Bilbao, Spain, in order to ascertain and agree upon or as noted otherwise, the cause, the nature and extent, and the recommended repair, of damage alleged to have been sustained in consequence of the vessel grounding and having stranded in the Delaware River, Pa. U.S.A., whilst on a laden voyage from Marcus Hook, Pa., to Bilbao, Spain, on December 17, 1972.

DESCRIPTION

This vessel is one of the new motor container ships of this Owner's fleet, built in 1968, with machinery aft and seven holds. All holds are designed and fitted for the stowage of containers. This vessel is equipped with diesel motor propulsion machinery of 28500 B.H.P.

ATTENDING

Mr................, Representing Ship Cargo Inc..
Mr................, Representing ....
Mr................, Representing ....
Mr................, Representing Nervion Shiprepairers Co..

ABSTRACT OF DECK LOG

Voyage - Marcus Hook Pa., to Bilbao, Spain, in loaded condition.

December 17, 1972.

1535 - Completed loading. Hatches battened down and derricks secured. Draft 33'-0" F 34'-0" A.

1640 - Pilot aboard

1655 - Commenced singling up Fore and Aft.

1700 - Tugs alongside - "Edith Moran" for'd. "Henry Moran" aft.

1712 - Tugs all fast.

1716 - Cast off fore and aft and left berth. Swinging off berth.

1743 - Vessel swinging off berth - let go tugs and proceeded down river to Pilot's advice. Wind N.W. Force 7-8.

1845 - Heavy squall accompanied by heavy snow shower. Wind N.W. Force 10. Visibility nil.

1848,- Speed reduced to slow. Additional lookout posted forward. Ch. Officer - and Carpenter standing by forward to anchor

1903 - Vessel grounded on N.E. side of Delaware River. Various engine movements to refloat vessel unsuccessful.

1952 - Soundings taken round vessel show vessel aground along port side from No. 1 hatch where depth of water 30 feet to aft where depth 32'-6". Wind N. Force 7. Bilges and double bottoms all sounded round - no leakage found.

2045 - Tug "Henry Moran" alongside to assist in refloating and connected up on starboard side aft.

2105 - Tug fast and commenced assisting vessel to refloat. manoeuvring ship's engines - tug assisting vessel to refloat.

2218 - Vessel afloat using ship's engines and Tug "Henry Moran" assisting.

2225 - Cast off tug and proceeded. Wind N.W. Force 6-7. Weather now clear with occasional light snow showers. Proceeded down river - engines and courses to Pilot's advice.

2310 - Ch. Engineer reports main condenser fouled.

2315 - Stop.

2328 - Let go port anchor.

2335 - Brought up to 3 shackles on port anchor. Engineers cleaning main condenser and which fouled due to grounding.

December 18, 1972

0350 - Commenced weighing anchor.

0400 - Anchor aweigh and vessel proceeded - Engines and Courses to Pilot's advice. Wind N.W. Force 6.
Ch. Engineer reports further cleaning of condenser necessary at a suitable opportunity

FOUND	RECOMMENDED
BOTTOM SHELL PLATING (Plates numbered from aft as per shell expansion plan)	
KEEL PLATING.	
1. Keel plate FK-24 heavily indented bodily over full length to a maximum depth of approximately 75 mm	1. To be renewed Size: 5950 mm x 2180 mm x 27.5 mm
2. Keel plate FK-25 scored and heavily indented to maximum depth of approximately 50 mm over full width for forward three quarters length	2. To be renewed. Size: 5650 mm x 2180 mm x 27.5 mm
PORT SIDE.	
3. Garboard Strake A-24 scored and indented bodily to a maximum depth of approximately 90 mm. over full area	3. To be renewed. Size: 5950 mm x 2155 x 20.5 mm.
4. Garboard strake A-25 scored and heavily indented to a maximum depth of approximately 80 mm. over inboard half width for after half length.	4. To be cropped and partly renewed. Size of renewed section: 3100 mm x 2155 mm x 20.5 mm.
5. Plate B-24 moderately indented between floors in way of inboard seam for after half length	5. To be released locally heated and faired in place over an area of approximately 5 sq. metres.
STARBOARD SIDE	
6. Garboard strake A-24 scored and indented bodily to a maximum depth of 80 mm. over full area	6. To be renewed. Size: 5950 mm x 2155 mm x 20.5 mm.

FOUND	RECOMMENDED
7. Garboard strake A-25 slightly indented between floors at aft end of plate butt and inboard seam.	7. To be released locally, heated and faired in place over an area of approximately 2 sq. metres.
INTERNALS. NO. 1 DOUBLE BOTTOM TANK PORT SIDE	
8. Centre girder moderately buckled at shell connection in way of damaged keel plates FK-24 and Fk-25.	8. To be released locally, heated and faired in place over eleven frame spaces, and resecured. Area faired in place approximately 4.5 sq. metres.
9. Ten transverse floors buckled moderately to heavily in way of damaged bottom plates	9. Ten floors to be cropped and partly renewed. Size of renewed sections: 3400 mm x 350 mm x 14.5 mm.
10. Two shell longitudinals in way of damaged keel plates FK-24 & FK-25 A strake plates 24 & 25 heavily buckled	10. To be cropped and partly renewed. Size of renewed sections: 1 @ 12100 mm x 9" x .38" OBP. 1 @ 9300 mm x 9" x .38" OBP.
11. Double bottom side girders at 1400 mm and 2900 mm off centre line moderately to heavily buckled at shell connection.	11. To be cropped and partly renewed Size of renewed sections: 1 @ 9100 mm x 350 mm x 12 mm. 1 @ 5000 mm x 250 mm x 12 mm.
NO. 1 DOUBLE BOTTOM TANK STARBOARD SIDE	
12. Seven transverse floors buckled heavily in way of damaged bottom plates.	12. Six floors to be cropped and partly renewed. Size of renewed sections: 3300 mm x 360 mm x 14.5 mm. each One floor to be released locally, heated and faired in place over an area of approximately 1 sq. metre and resecured.

FOUND	RECOMMENDED
13. Two shell longitudinals in way of damaged keel plates FK-24 & FK-25 and A strake 24, heavily buckled.	13. To be cropped and partly renewed. Size of renewed sections: 1 @ 12100 mm x 9" x .38" OBP. 1 @ 6500 mm x 9" x .38" OBP.
14. Double bottom side girders at 1400 mm and 2900 mm off centre line moderately buckled at shell connection	14. To be cropped and partly renewed. Size of renewed sections 2 @ 6300 mm x 250 mm x 12 mm.
MISCELLANEOUS	
15. Main condenser subjected to fouling.	15. To be opened up, cleaned, and reassembled in good order.
16. Main condenser pump subjected to fouling.	16. To be opened up, cleaned, and reassembled in good order.
17. Five sea valves and strainers subjected to fouling.	17. To be opened up, cleaned, and reassembled in good order.

NOTES.

A. Necessary drydocking to effect repairs.
B. Necessary tug assistance into and out of drydock.
C. Necessary Riggers to handle mooring lines and gangway.
D. Necessary cleaning of No. 1 port and starboard double bottom tanks in way of repairs. (Salt water ballast tank).
E. Necessary removal of 12 keel blocks in way of repairs and installation of 10 side shores, which are to be removed upon completion of damage repairs.
F. Necessary removal of debris from No. 1 port and starboard double bottom tanks on completion of repairs.
G. Necessary removal of pipes etc., in No. 1 double bottom tanks, port and starboard, for access to repairs and thereafter replaced as originally.
H. All new and repaired work to be tested and proven tight.
I. The following drydock services to be supplied, including connecting up and disconnecting as applicable.
    Fire line.
    Circulating water for vessel's refrigerating system.
    Electricity for lighting, heating, cooking and other living purposes.

Fresh water for drinking and sanitary purposes.
Garbage removal.
Telephones.

J. Necessary prime coating of external surfaces of new and repaired work in Items 1 to 7 inclusive.

K. Value of scrap material from this repair to be credited.

The Nervion Shiprepairing Company submitted a price in the amount of Pesetas ...., to effect the foregoing repairs, including a scrap credit of Pesetas ...... This price is considered fair and reasonable.

It was agreed that if carried out alone, the foregoing repairs would require:

Drydocking: Note A.

One haul day at Pesetas	Pesetas	
Seven lay days at Pesetas	Pesetas	________
TOTAL	Pesetas	

Drydock services - Note I .... Pesetas

SURVEYOR'S NOTES

The foregoing repairs were carried out concurrently with Owner's work and repairs of one other damage as described in the following report :

CASE NO. 00-0000 - Contact Damage - September 16, 1972.

Owner's work consisted of drydocking vessel for underwater -examination, ranging of anchors and cables, examination of sea valves, cleaning and painting the underwater body and minor repairs to bottom plating, all of which, if done alone, would have required - three days in drydock.

Arrival of vessel at repair area-------	2 A.M.	8-1-73.
In drydock ----------------------------	7 A.M.	8-1-73.
Completion of damage repairs ----------	2 P.M.	15-1-73
Off Drydock----------------------------	5 P.M.	15-1-73.
Departure of vessel from repair area --	11 A.M.	16-1-73

Tailshaft clearance at this time was 3 mm.

Repairs were checked, found carried out according to survey and all work done as specified.

Survey made without prejudice, and subject to adjustment.

____

Surveyor for United States
Salvage Association, Inc..

APPENDIX 7

United States Salvage field survey report—stranding damage.

FIELD SURVEY REPORT

M. S. "SAMPLE" January 10, 1973.

We, the undersigned, have, on January 8 and 10, 1973, held survey on the M. S. "SAMPLE", 30000 tons gross, 123456 Official Number, Ship Cargo Inc., Owners, Newship Corp., Operators, whilst lying in drydock at the yard of Nervion Shiprepairing Co., Bilbao, Spain, in order to ascertain and agree upon or as noted otherwise, the cause, the nature and extent, and the recommended repair, of damage alleged to have been sustained in consequence of the vessel grounding and having stranded in the Delaware River, Pa., U.S.A., while on a laden voyage from Marcus Hook, Pa., to Bilbao, Spain, on December 17, 1972.

FOUND	RECOMMENDED
BOTTOM SHELL PLATING. (Plates numbered from aft as per shell expansion plan.)	
KEEL PLATING.	
1. Keel plate FK-24 heavily indented bodily over full length to a maximum depth of approximately 75 mm.	1. To be renewed. Size: 5950 mm x 2180 mm x 27.5 mm.
2. Keel plate FK-25 scored and heavily indented to a maximum depth of approximately 50 mm. over full width for forward three quarters length	2. To be renewed. Size: 5650 mm x 2180 mm x 27.5 mm.
PORT SIDE	
3. Garboard strake A-24 scored and indented bodily to a maximum depth of approximately 90 mm. over full area.	3. To be renewed. Size: 5950 mm x 2155 mm x 20.5 mm.
4. Garboard strake A-25 scored and heavily indented to a maximum depth of approximately 80 mm. over inboard half width for after half length.	4. To be cropped and partly renewed. Size of renewed section: 3100 mm x 2155 mm x 20.5 mm.
5. Plate B-24 moderately indented between floors in way of inboard seam for after half length.	5. To be released locally, heated and faired in place over an area of approximately 5 sq. metres.

FOUND	RECOMMENDED
STARBOARD SIDE.	
6. Garboard strake A-24 scored and indented bodily to a maximum depth of 80 mm. over full area.	6. To be renewed. Size: 5950 mm x 2155 mm x 20.5 mm.
7. Garboard strake A-25 slightly indented between floors at aft end of plate butt and inboard seam.	7. To be released locally, heated and faired in place over an area of approximately 2 sq. metres.
INTERNALS NO. 1 PORT DOUBLE BOTTOM TANK.	
8. Centre girder moderately buckled at shell connection in way of damaged keel plates FK-24 and FK-25.	8. To be released locally, heated and faired in place over twelve frame spaces, and resecured. Approximate area faired in place 4.5 sq. metres.
9. Ten transverse floors buckled moderately to heavily in way of damaged starboard bottom plates.	9. Ten floors to be cropped and partly renewed. Size of renewed sections: 3400 mm x 350 mm x 14.5 mm. each.
10. Two shell longitudinals in way of damaged keel plates FK-24 & 25 and A strake plates 24 & 25 heavily buckled.	10. To be cropped and partly renewed. Size of renewed sections: 1 @ 12100 mm x 9" x .38" OBP. 1 @ 9300 mm x 9" x .38" OBP.
11. Double bottom side girders at 1400 mm and 2900 mm off centre line moderately to heavily buckled at shell connection.	11. To be cropped and partly renewed. Size of renewed sections: 1 @ 9100 mm x 350 mm x 12 mm. 1 @ 5000 mm x 250 mm x 12 mm.
NO. 1 STARBOARD DOUBLE BOTTOM TANK	
12. Seven transverse floors buckled heavily in way of damaged bottom plates.	12. Six floors to be cropped and partly renewed. Size of renewed sections: 3300 mm x 360 mm x 14.5mm. each

FOUND	RECOMMENDED
	One floor to be released locally, heated and faired in place over an area of approximately 1 sq. metre and resecured.
13. Two shell longitudinals in way of damaged keel plates FK-24 & 25 and A strake 24. Heavily buckled.	13. To be cropped and partly renewed. Size of renewed sections: 1 @ 12100 mm x 9" x .38" OBP. 1 @ 6500 mm x 9" x .38" OBP.
14. Double bottom side girders at 1400 mm and 2900 mm off centre line moderately buckled at shell connection.	14. To be cropped and partly renewed Size of renewed sections: 2 @ 6300 mm x 250 mm x 12 mm.
MISCELLANEOUS	
15. Main condenser subjected to fouling.	15. To be opened-up, cleaned, and reassembled in good order.
16. Main condenser pump subjected to fouling.	16. To be opened up, cleaned, and reassembled in good order.
17. Five sea valves and strainers subjected to fouling	17. To be opened up, cleaned, and reassembled in good order.

NOTES.

A. Necessary drydocking to effect repairs. (1 haul and 7 lay days)

B. Necessary tug assistance into and out of drydock.

C. Necessary Riggers to handle mooring lines and gangway.

D. Necessary cleaning of no. 1 port and starboard double bottom tanks in way of repairs. (Salt water ballast tank)

E. Necessary removal of 12 keel blocks in way of repairs and installation of 10 side shores, which are to be removed upon completion of damage repairs.

F. Necessary removal of debris from No. 1 port and starboard double bottom tanks on completion of repairs.

G. Necessary removal of pipes etc., in No. 1 port and starboard double bottom tanks, for access to repairs, and thereafter replaced as originally.

H. All new and repaired work to be tested and proven tight.

I. The following drydock services to be supplied, including connecting up and disconnecting as applicable.
   Fire line.
   Circulating water for vessel's refrigerating system.
   Electricity for lighting, heating, cooking and other living purposes.
   Fresh water for drinking and sanitary purposes.
   Garbage removal.
   Telephones.

J. Necessary prime coating of external surfaces of new and repaired work in items 1 to 7 inclusive.

K. Value of scrap material from this repair to be credited.

The Nervion Shiprepairing Co., agrees to effect the foregoing repairs for the sum of Pesetas ...., including a scrap credit of Pesetas .... This price is considered fair and reasonable, and was reached by agreement on an item-by-item basis.

It is agreed that the damages set forth in Items 1 to 14 inclusive could be directly attributed to the alleged stranding.

It is also agreed that to perform the recommended repairs as per Items 1 to 14 inclusive, all of Notes A, B, C, D, E, F, G, H, I and J would be required, and 100% of Note K would be credited.

ITEM	PRICE PESETAS	NOTES.	PRICE PESETAS
1	....	B	....
2	....	C	....
3	....	D	....
4	....	E	....
5	....	F	....
6	....	G	....
7	....	H	....
8	....	I	....
9	....	J	....
10	....	K	....
11	....		
12	....		
13	....		
14	....		
15	....		
16	....		
17	....		

Survey made without prejudice

(Signature)................ Mr.______ Representing Ship Cargo Inc.,	(Signature)................ Mr.______ Representing United States Salvage Association Inc..
(Attended but did not sign) Mr.______ Representing	(Signature)................ Mr.______ Representing The Nervion Shiprepairers Co.,

APPENDIX 8

United States Salvage field survey report—common charges.

FIELD SURVEY REPORT

M.S. "SAMPLE" January 10, 1973

We, the undersigned, have, on January 8 and 10, 1973, held survey on the M. S. "SAMPLE", 30000 tons gross, 123456 Official Number, Ship Cargo Inc., Owners, Newship Corp., Operators, whilst lying in drydock at the yard of Nervion Shiprepairing Co., Bilbao, Spain, and find the following necessary charges common to the damage repairs which are being effected concurrently for the following incidents:

1. Contacted Dock Wall, September 16, 1972. If done alone, would require one haul day and two lay days in drydock.
2. Stranding, December 17, 1972. If done alone, would require one haul day and seven lay days in drydock.

Total Drydocking - All Repairs:

One haul day at Pesetas .... Pesetas ....
Seven lay days at Pesetas .... Pesetas ....

Common Charges - All Repairs.

Tug assistance into and out of drydock .... Pesetas ....
Riggers into and out of drydock .... Pesetas ....
Drydock services for eight days including connecting up and disconnecting as applicable.
Fire line ....
Circulating water for vessel's refrigerating system. ....
Electricity for lighting, heating, cooking and other living purposes ....
Garbage removal ....
Telephones ....
Total.-------------------------- Pesetas ....

Grand Total Pesetas

Survey made without prejudice

(Signature)............... Mr. ________ Representing Ship Cargo Inc..

(Signature)..................... Mr. ___________ Representing United States Salvage Association, Inc..

(Signature)................ Mr. ________ Representing

(Signature) .... Mr. ___________ Representing Nervion Shiprepairers Co..

APPENDIX 9

United States Salvage memorandum of separation of damage.

UNITED STATES SALVAGE ASSOCIATION, INC.

MEMORANDUM

Bilbao, Spain.
January 20, 1973.

TO United States Salvage Association, Inc..

FROM (Surveyor's Name)

SUBJECT: M. S. "SAMPLE"
Stranding.
December 17, 1972.
Case No. 00-0000

It was requested, prior to this survey that separation between damage resultant from stranding and damage resultant from efforts to refloat would be required.

It was mutually agreed amongst all interested Principals in attendance at this survey that the damages set forth in Items 1 to 14 inclusive, could be directly attributed to the alleged stranding.

It was further agreed that in order to perform the recommended repairs as per Items 1 to 14 inclusive, all of Notes A, B, C, D, E, F, G, H, I and J would be required and 100% of Note K would be credited.

Agreed Item and Note prices:

ITEM	PRICE PESETAS	NOTES	PRICE PESETAS
1	....	A	....
2	....	B	....
3	....	C	....
4	....	D	....
5	....	E	....
6	....	F	....
7	....	G	....
8	....	H	....
9	....	I	....
10	....	J	....
11.	....	K	....
12.	....		
13	....		
14	....		
15	....		
16	....		
17	....		

It was further agreed that :

Items 15 and 16, if repaired alone, would have required two working - days afloat.

Item 17, if repaired alone, would have required two working days in drydock.

____

Surveyor for United States
Salvage Association, Inc..

APPENDIX 10

Specimen damage report for owners.

LLOYD'S REGISTER OF SHIPPING

71, Fenchurch Street, London, EC3M 4BS

Report No. 00.
Bilbao, Spain.
20th January, 1973.

THIS IS TO CERTIFY THAT at the request of the Owner's Representative, the undersigned Surveyor to this Society attended on board the M.S. "SAMPLE", 30000 tons gross of Monrovia, on the 8th January, 1973, and subsequently, while the vessel lay in drydock at Bilbao, Spain for the purpose of ascertaining the cause, nature and extent of damage stated to have been sustained in the following circumstances:-

Damage (1). Contact at Kandera, India, on 16.9.1972.

Whilst berthing at Kandera, India, the vessel contacted Pier No. 40, sustaining damage to starboard side shell plating aft in way of oil fuel bunker at forward end of Engine Room.

Damage (2). Stranding in Delaware River, Pa., U.S.A. on 17.12.1972.

Whilst proceeding down the Delaware River, the vessel grounded and lay stranded at 1903 hours, refloating at 2218 hours the same day, using the main engines and assisted by Tug "Henry Moran".

Damage (2a). Efforts to Refloat on 17.12.1972.

For further particulars, please refer to the vessel's log books, written in the Greek language, which have not been sighted.

The above is based on the Master's report of the incidents.

Upon examination, the following damage was found and repairs recommended without prejudice to the terms and conditions of insurance.

This Certificate is issued upon the terms of the Rules and Regulations of the Society, which provide that:—

"The Committees of the Society use their best endeavours to ensure that the functions of the Society are properly executed, but it is to be understood that neither the Society nor any Member of any of its Committees nor any of its Officers, Servants or Surveyors is under any circumstances whatever to be held responsible or liable for any inaccuracy in any report or certificate issued by the Society or its Surveyors, or in any entry in the Register Book or other publication of the Society, or for any act or omission, default or negligence of any of its Committees or any Member thereof, or of the Surveyors, or other Officers, Servants or Agents of the Society".

N. (Rpt. 10c.—Lon.) 2m.10,71 (MADE AND PRINTED IN ENGLAND)

-2-

Damage (1).

FOUND		RECOMMENDED
....	:	....
....	:	....
....	:	....
....	:	....

Damage (2).

FOUND		RECOMMENDED
....	:	....
....	:	....

Damage (2a).

FOUND		RECOMMENDED
....	:	....
....	:	....
....	:	

RECOMMENDATIONS.

Vessel to be drydocked to effect damage repairs, keel blocks to be removed in way of repairs in No. 1 D.B. Tank and necessary side shores installed and removed upon completion of repairs.

Staging to be erected as necessary and thereafter dismantled on completion of repairs.

Tanks to be cleaned as necessary for repairs and gas free certificates for hot work to be provided where applicable.

All new and repaired work to be proven tight as applicable.

All removals necessary for access to repairs be replaced satisfactorily and that all new and disturbed steelwork be coated as originally.

The above recommendations were made with a view to restoring the vessel to the same condition as existed before the alleged casualties occurred and all repairs have now been completed to my satisfaction.

CAUSE.

In my opinion, the damages as noted above are reasonably attributable to the alleged causes on the information available.

REPAIR CHARGES.

The above recommended repairs have been carried out by Nervion Shiprepairers Company, Bilbao, Spain at a total cost of:-

Damage (1) - Pesetas ....

Damage (2) - Pesetas ....

Damage (2a) - Pesetas ....

Which costs have been agreed to by the Owner's Representative and are considered by the undersigned to be fair and reasonable.

DRYDOCKING CHARGES.

The vessel entered the drydock of Nervion Shiprepairing Company on the 8th January, 1973 when repairs were commenced and undocked on the 15th January, 1973, when repairs were completed, and the cost for eight days in drydock amounted to Pesetas ....

....

Surveyor to Lloyd's Register of Shipping.

APPENDIX 11

Survey data list.

As can be seen from the preceding examples of damage reports, all relevant information must be incorporated to entirely satisfy underwriters and adjusters. As a reminder therefore, the following survey data is noted hereunder for guidance purposes.

Not all of these items (marked thus *) are required for inclusion in the damage report, but nevertheless, they are relevant and may lead the Surveyor to enquire further.

Vessel's name:
Port of registry:
Gross tons:
*Class:
*If L.R., state of class:
Last drydocking:
*S.R.L. items:
*S.R.L. Appendix items:
Report No.:
Case No. (U.S. Salvage):
Date of instructions:
At the request of:
On behalf of:
Surveyed at:
Afloat and/or in drydock:
First date of survey:
Name of owners' representative and status:
Name of class representative and society:
Name of others and details:
Date of docking:
Date of undocking:
Whether drydock necessary:
Date of commencement of repairs:
Date of completion of repairs:
Alleged casualty(s) and date(s):
Log books/extracts examined from/to
Vessel in loaded/ballast condition:
On voyage from .... to ....
Date of vessel leaving port:
Permanent repairs (part) effected/deferred:
Temporary repairs (part) effected:
Details of any other damage/owners' repairs effected concurrently:
Owners' repairs necessary for seaworthiness?:
If so, estimate time required afloat and in drydock:
Estimate times of damage repairs, if carried out separately:
Afloat: .... In Drydock: ....
Overtime worked, number of days saved:
Afloat: .... In Drydock: ....
Agreed cost of repairs—each damage:
Cost of drydocking:
Cost of general services:
Excess cost of overtime:
Values of credits:
Is damage consistent with cause alleged?:

In addition to the above, the following data should be noted in cases of:

Collision damage

Names of vessels:
Time and place of casualty:
Course of vessels:
Speeds of vessels:
Draughts of vessels:
Angle of blow (shown in sketch):
Avoiding action taken:
Weather and visibility reported at time of collision:
Efforts to extricate collided vessels:
Photographs:
Condition of:
whistle,
navigation lights,
steering gear,
bridge/engine room telegraph.
Separation of collision damage and extrication damage:

Grounding/stranding

Events leading to casualty:
Place of grounding:
Date and time of casualty:
Draft of vessel, F...................., A....................
Sounding taken around vessel at position of grounding:
Weather and visibility reported at time of grounding:
Efforts to refloat:
Time of refloating:
How refloated: e.g. Using main engines, using anchors and cables, assisted by tugboats, etc.
Separation of grounding/stranding damage and efforts to refloat:

Heavy weather

Wind force and direction:
Loaded/ballast condition:
Voyage from .... to ....
Dates covering heavy weather:

Fire

Cause and time of fire:
How extinguished and when:
Efforts to extinguish:
Separation of fire damage and fire extinguishing damage:

Loss of earnings survey

Time and date of:
(a) the diversion of the vessel from its regular trade route:
(b) the arrival of the vessel at a repair facility or port of refuge:
(c) the commencement and completion of survey:
(d) the return of the vessel to its original trade interrupted by the casualty:
(e) the commencement and completion of repairs:

Owners' work, if any, carried out concurrently with the damage repairs:
Overtime worked, if any, and time saved thereby:
Time taken to steam and clean tanks, if applicable:
Time taken to discharge and reload cargo, if applicable:

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Lloyd's Register Technical Association

SOME PRACTICAL ASPECTS OF MOULDING G.R.P. YACHTS AND SMALL CRAFT

J. Tyler and R. Musters
(Guest Speakers)

Paper No. 4. Session 1974-75

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Hon. Sec. A. Wardle
71, Fenchurch Street, London, EC3M 4BS

SOME PRACTICAL ASPECTS OF MOULDING G.R.P. YACHTS AND SMALL CRAFT

A guest paper presented to Lloyd's Register Technical Association by Messrs. J. Tyler and R. Musters of the Tyler Boat Co. Ltd. Mr., the President, F. H. Atkinson in the Chair.

TABLE OF CONTENTS

1. INTRODUCTION
2. RESIN/GLASS RATIO. MAT LAMINATES
   - 2.1 Flexural strength
   - 2.2 Shear strength
   - 2.3 Tensile strength
3. RESIN
4. SHELL LAMINATE
5. FRAMING AND STIFFENING
6. TYTON CONSTRUCTION
7. BULKHEAD CONNECTIONS
8. TANKS
9. ENGINE BEDS AND GIRDERS
10. FLOORS
11. LIMBER HOLES
12. OVERALL WEIGHT AND THICKNESS OF HULL STRUCTURE
13. KEEL BOLTS
14. DECK EDGE JOINTS
15. KNEES
16. FENDERING
17. RUDDERS
18. CENTREBOARDS
19. ENGINE AND STERN GEAR INSTALLATION

Frontispiece: the first Victory 48 completed by Anna Wever in Holland and known there as Trintella V. Six of these have already been moulded, some of them under supervision.

1. INTRODUCTION

Over the last 13 years Tyler Boats have moulded over 2000 yachts and small craft. During this period an amount of technique and experience has been built up. This paper outlines some of these techniques.

2. RESIN/GLASS RATIO. MAT LAMINATES

2.1 Flexural strength

Although the highest specific flexural strength is obtained at around 1·5 : 1 resin/glass ratio, at higher ratios the lower specific flexural strength is more than compensated for by the increased thickness. A 2·5 : 1 resin/glass ratio produces a laminate capable of withstanding double the load as compared to the same weight of reinforcement at 1·5 : 1.

2.2 Shear strength

Within the range 1·5–2·5 : 1, resin/glass ratio has comparatively little effect on shear strength, best results have been obtained around 2·0–2·5 : 1.

2.3 Tensile strength

The optimum is around 2·0 : 1, greater thickness does not increase the tensile strength. It is interesting to note that mat laminate at 2·5 : 1 resin/glass ratio has approximately the same tensile strength as woven roving laminate at 1 : 1 resin/glass ratio with the same glass content.

3. RESIN

A good quality isophthalic gelcoat resin is essential to protect the moulding. The particular qualities required are,

(a) Low water absorption.
(b) High heat distortion temperature.
(c) Durability.
(d) Flexibility.

The water absorption quoted, to B.S.3532, may be misleading as this test is only over a 24 hour period and a longer test may produce quite different results. In general orthophthalic resins absorb less water than isophthalic in the short term, but appreciably more in the long term.

It is not possible to achieve the optimum resin/glass ratio of around 2·25 : 1 mentioned above, without a resin of suitable viscosity. Fig. 1 shows the relationship between viscosity and resin/glass ratios for mat laminates. These figures should only be taken as a general guide as the resin/glass ratio is also dependent on the type of mat, laminating technique and resin temperature.

The requirements of a good laminating resin are,

(a) Suitable viscosity.
(b) Low water absorption.
(c) High heat distortion temperature.

Unfortunately the figures quoted by resin manufacturers to British Standards for both water resistance and heat distortion refer only to cast resin and may be an unreliable guide to laminate performance.

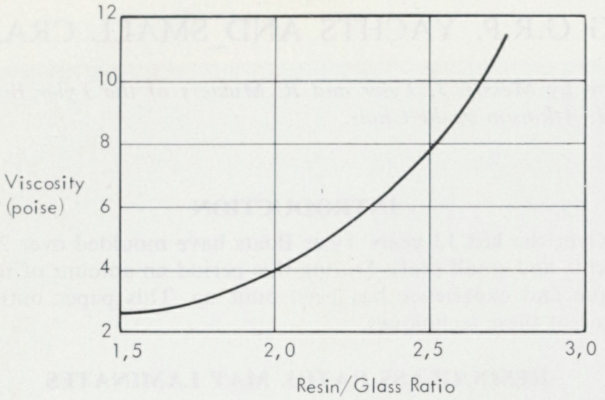


FIG. 1

Relationship between viscosity and resin/glass ratio.

4. SHELL LAMINATE

Clear gelcoats are now accepted as having the best water resistance. Above the waterline, Tylers apply two coats of pigmented gel to ensure adequate water resistance and depth of colour.

A light chopped strand mat (C.S.M.) is used next to the gelcoat for ease of wetting out without trapping air. Surface tissues do not drape well, due to the amount of binder needed to hold them together and trap more air than a light mat. Spray rails and chines require special care, another two light mats applied in strip form.

Another 450 gms/m^2 ($1\frac{1}{2}$ oz/ft^2) of C.S.M. should be laid before the first layer of woven roving, 900 gms/m^2 (3 oz/ft^2) if metal rollers are being used, to prevent the woven pattern showing through the gelcoat. This conflicts, to some extent, with the desirability of having the woven roving near the inner and outer surfaces where the stresses, due to simple bending, are highest.

When calculating the shell laminate of stiffened hulls, the type of stiffener used may appreciably affect the effective span of the shell between stiffeners. Fig. 2 shows web stiffeners with bonded connections and hat stiffeners with bonded connections. A good case could be made for using the distance between stiffeners as the design criteria, in place of the traditional centre to centre distance.

On larger craft where the weight of each part of the structure is appreciably greater, the effect of aggregation needs to be considered. Fig. 3 shows hat stiffeners with continuous or joined stiffener laminate. In this case the combined thickness (T) should be considered in relation to the span (S). Whilst the basic thickness (t) will be dependent on the width of stiffener base (s).

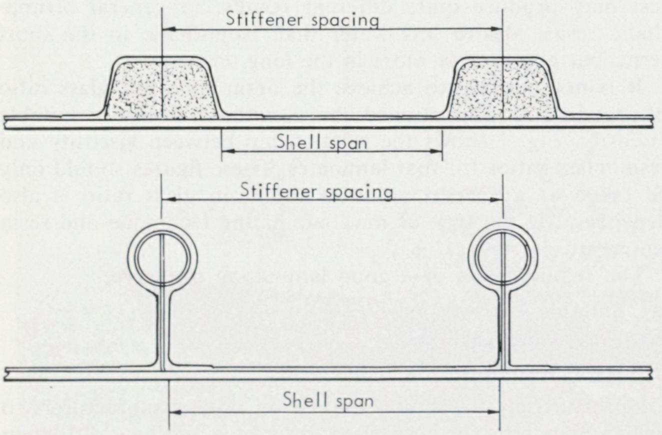


FIG. 2

Effect of stiffener shape on shell span.

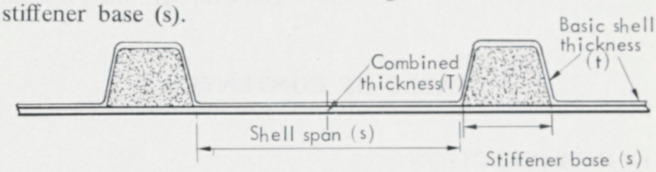


FIG. 3

Hat stiffeners with continuous laminate.

5. FRAMING AND STIFFENING

Notwithstanding the foregoing argument, the scantlings of the combined shell and stiffener should be considered on a centre to centre basis.

It is noted that it is the Society's current practice to assume a resin/glass ratio of 2·3 : 1 and a thickness of 0·0267 in/oz C.S.M. in assessing stiffener laminates. This reduced resin/glass ratio increases the tensile strength from 91MN/m^2 (13 000 p.s.i.) to 98MN/m^2 (14 000 p.s.i.), which should lead to a proportionate reduction in the required section modulus. Uni-directional rovings can be used with particular advantage in stiffener faces as their tensile strength is double that of woven rovings for the same weight of glass.

Longitudinal framing is simpler than transverse. The stiffeners can be laminated when the moulds are laid flat before joining and there are fewer of them. Transverse framing is better for larger hulls where the loadings are higher and the bulkheads may be insufficient to support longitudinals. Transverse frames should be continuous from gunwale to gunwale, over skegs and bilge keels, through girders and tanks. This involves more joints and it is important to plan the sequence of work correctly. If the skeg is not required for tankage, filling it with foam and covering with a light laminate, 900 gms/m^2 (3 oz/ft^2) C.S.M. makes a neat job and greatly facilitates framing.

6. TYTON CONSTRUCTION*

'Tyton' is a form of linked sandwich construction. After the outer skin is laid up, alternate strips of core material usually P.V.C. foam, are stuck to it with resin. These bevelled strips are then laminated over with the 'linking laminate' (Fig. 4). Similar strips of foam are then fitted in between the first set. The inner skin is laid up over both sets and the sandwich is complete.

The advantage over plain sandwich is that the 'linking laminate' takes the outer-skin shear and the integrity of the sandwich is not wholly dependent on the bond between the foam and glass fibre. The other advantages of sandwich construction also apply, namely bi-directional stiffness, acoustic and thermal insulation.

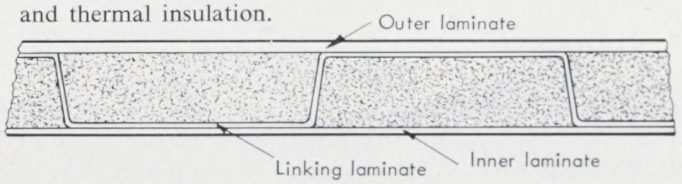


FIG. 4

Tyton construction.

* Regd. trade mark.

7. BULKHEAD CONNECTIONS

Fig. 5(a) illustrates the bulkhead connection used on small unstiffened yacht hulls. The hull is reinforced by way of the bulkhead. Fig. 5(b) illustrates the bulkhead connection used on longitudinally stiffened hulls. The bulkhead is notched to fit over the stiffeners which distribute the load in the fore and aft direction.

Alternatively, a transverse frame can be fitted between the longitudinal stiffeners to obviate notching the bulkhead (Fig. 5(c)).

Fig. 5(d) illustrates the bulkhead connection used on 'Tyton' sandwich hulls. The P.V.C. infill foam is replaced by end-grain balsa to increase the compressive strength in way of the bulkhead.

Fig. 5(e) illustrates the bulkhead connection used on transversely framed hulls. The frame face laminate can be reduced on bulkhead frames.

The bond between plywood and G.R.P. is improved by scouring the surface of the ply and priming it with a thinned coat of resin (an additional 10 per cent of styrene).

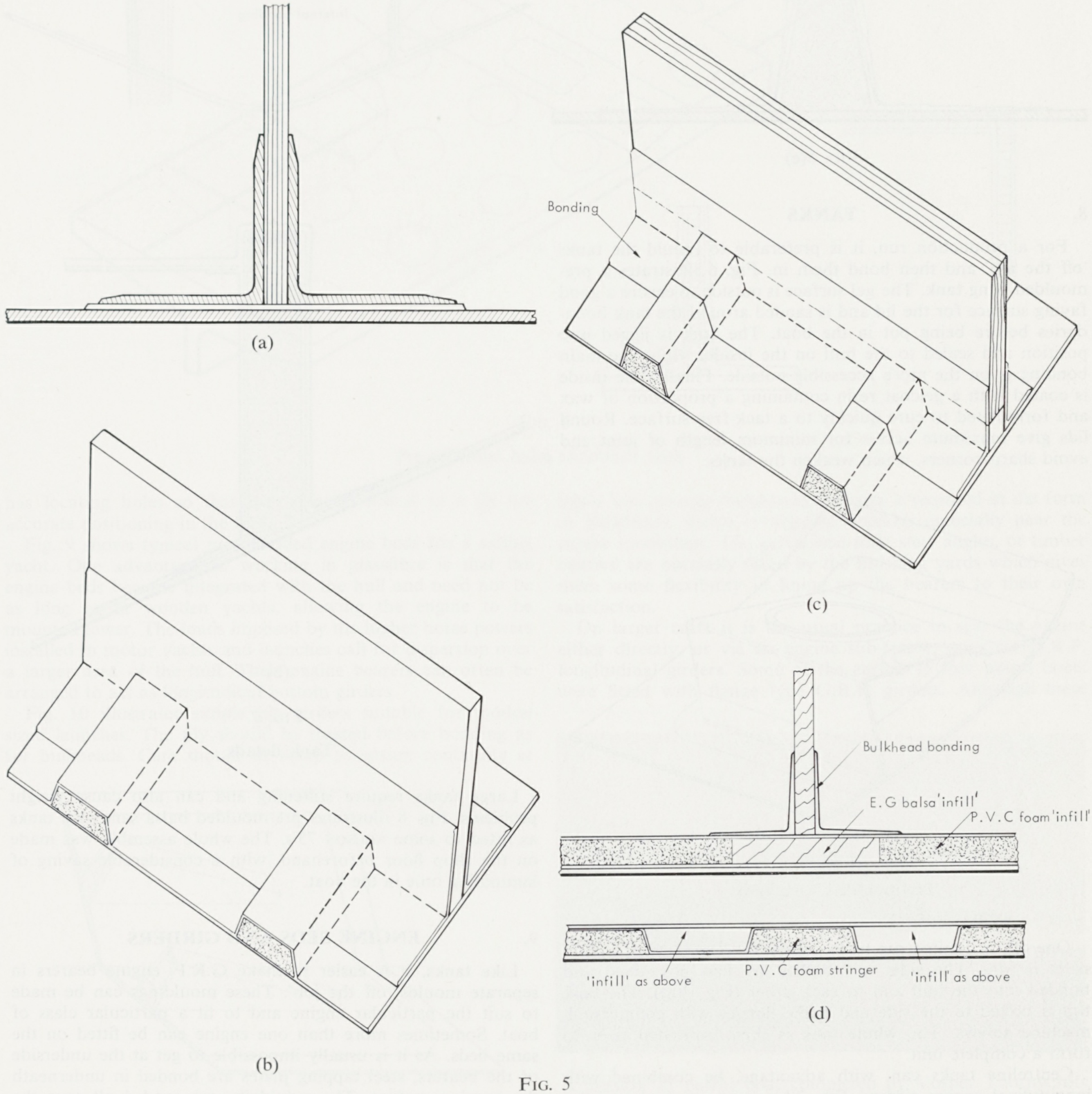


Fig. 5

Bulkhead connections.

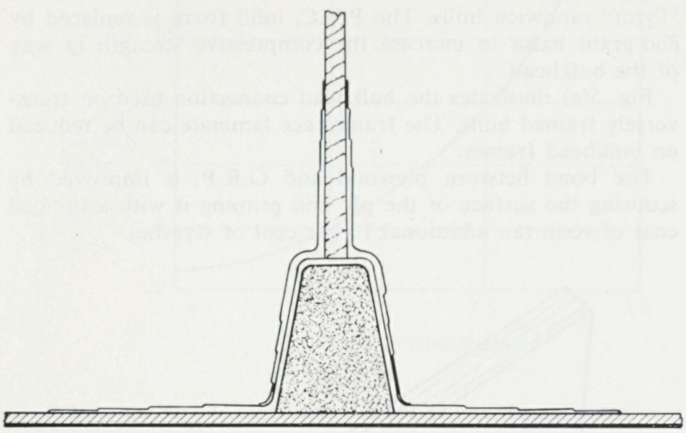


FIG. 5(e)

8. TANKS

For a production run, it is preferable to mould the tanks 'off the job' and then bond them in. Fig. 6 illustrates a pre-moulded wing tank. The gel surface is outside to ensure a good faying surface for the lid and is sanded around the tank boundaries before being put in the boat. The tank is jigged into position and sealed to the hull on the inside, whilst the main bonding is on the more accessible outside. Finally, the inside is coated with a gelcoat resin containing a proportion of wax and formulated to cure quickly to a tack-free surface. Round lids give maximum access for minimum length of joint and avoid sharp corners, which weaken the tanks.

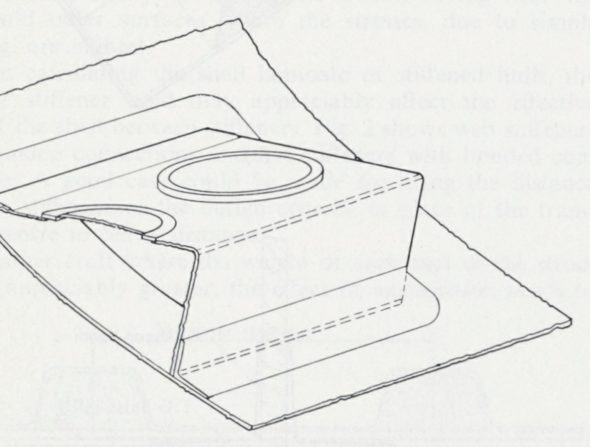
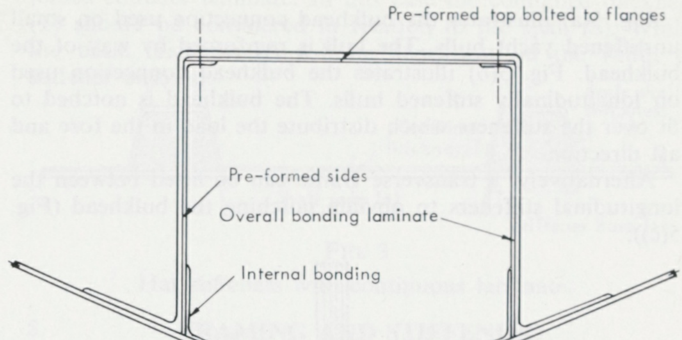


FIG. 6

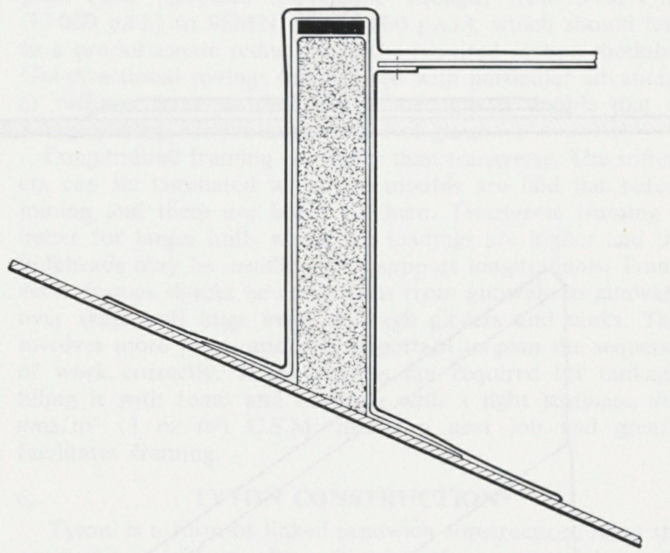
Pre-moulded wing tank.

One off, or limited run tanks can be fabricated from G.R.P. sheet *in situ*. The sides and baffles are first positioned and bonded into the hull and to each other (Fig. 7(a)). The tank top is bolted to the side and baffle flanges with countersunk machine screws. The whole tank is then laminated over to form a complete unit.

Centreline tanks can, with advantage, be combined with longitudinal engine girders. Fig. 7(b) shows an engine girder forming one side of such a tank.



(a)



(b)

FIG. 7

Tank details.

Large tanks require stiffening and can also cause weight problems. Fig. 8 illustrates pre-moulded balsa sandwich tanks as fitted to some NELSON 75's. The whole assembly was made on the shop floor beforehand, with a considerable saving of laminating time in the boat.

9. ENGINE BEDS AND GIRDERS

Like tanks, it is easier to make G.R.P. engine bearers in separate moulds 'off the job'. These mouldings can be made to suit the particular engine and to fit a particular class of boat. Sometimes more than one engine can be fitted on the same beds. As it is usually impossible to get at the underside of the bearers, steel tapping plates are bonded in underneath the bearing surface. The mouldings are sanded all over the bonding area before being put into the boat. Each moulding

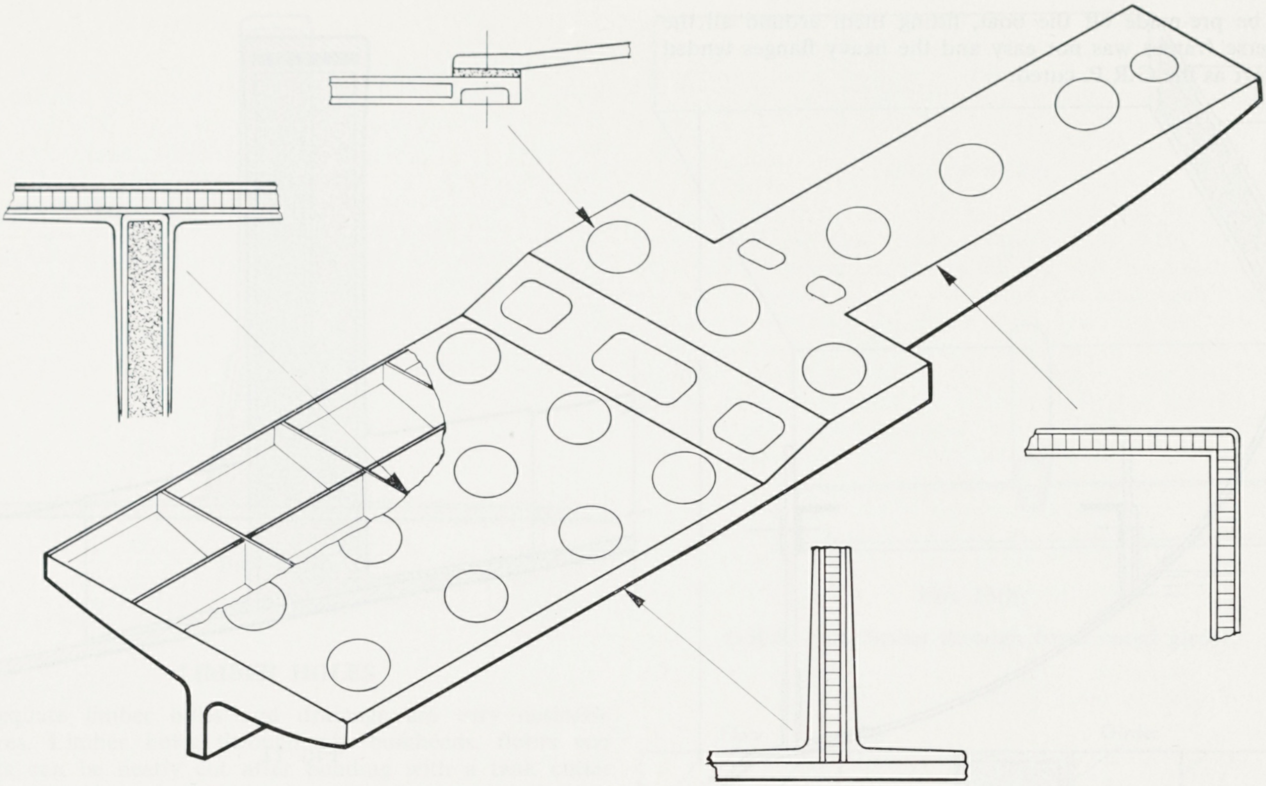


Fig. 8

Pre-moulded balsa sandwich tank.

has locating holes so that they can be bolted to a jig for accurate positioning in the hull.

Fig. 9 shows typical pre-moulded engine beds for a sailing yacht. One advantage of working in glassfibre is that the engine beds become integrated with the hull and need not be as long as in wooden yachts, allowing the engine to be mounted lower. The loads imposed by the higher horse powers installed in motor yachts and launches call for dispersion over a larger area of the hull. Their engine bearers can often be arranged to act as longitudinal bottom girders.

Fig. 10 illustrates simple ply girders suitable for modest sized launches. The ply should be treated before bonding as for bulkheads. Care should be taken to ensure continuity at joints and through bulkheads. Support is required in the form of bulkheads, floors or tripping brackets especially near the engine mountings. The galvanised mild steel angles, or timber bearers are normally fitted by the finishing yards which gives them some flexibility in lining up the bearers to their own satisfaction.

On larger craft it is the usual practice to seat the engine either directly, or via an engine sub-frame, onto the G.R.P. longitudinal girders. Some of the earlier 75-foot patrol boats were fitted with flange type G.R.P. girders. Although these

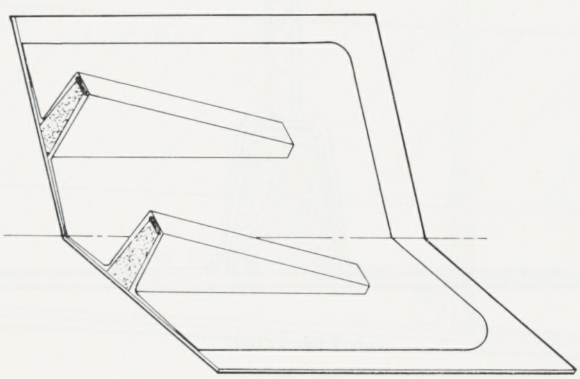


Fig. 9

Typical sailing yacht engine bed.

A NELSON 75 patrol boat completed by Vosper Thornycroft Ltd. Eight of these have been moulded under survey in the last two years.

could be pre-made off the boat, fitting them around all the transverse frames was not easy and the heavy flanges tended to distort as the G.R.P. cured.

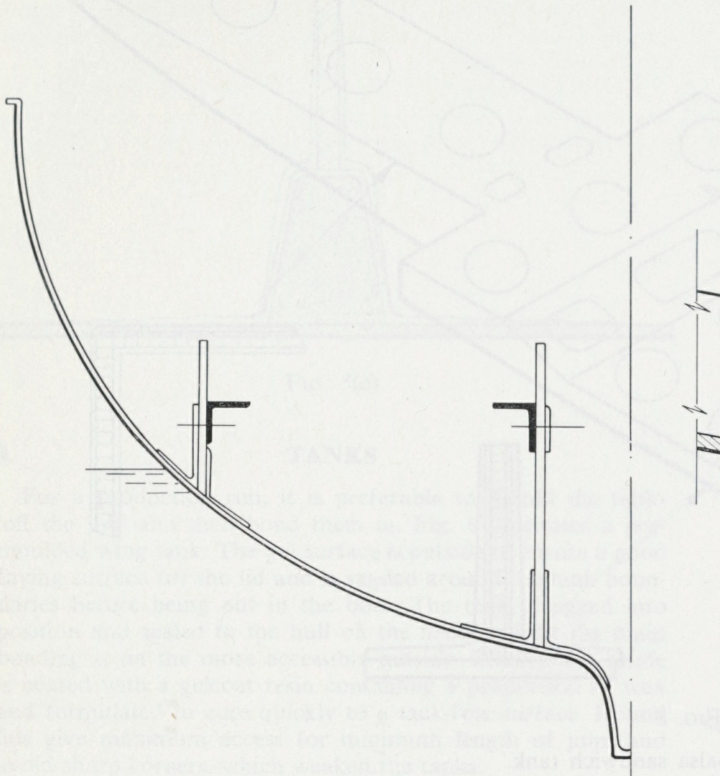


FIG. 10

Ply engine girders.

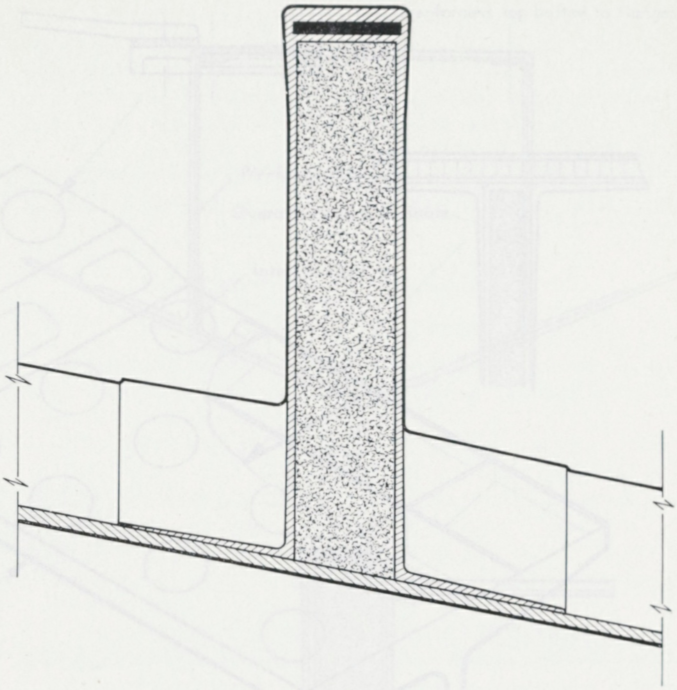


FIG. 11

G.R.P. engine girders.

Tylers have now reverted to using parallel sided polyurethane foam cored girders 80 kg/m³ (5 lb/ft³). Polyurethane foam of the required thickness is laminated over on both sides with 450 gms/m² ($1\frac{1}{2}$ oz/ft²) C.S.M. for ease of handling. The girder is then cut to shape and fitted in the boat. The girder can then be fully laminated *in situ* (Fig. 11) or removed for laminating on the shop floor and finally bonded in. The latter technique produces a particularly neat finish as resin spillage and G.R.P. build-up is kept to a minimum. Tapping plates are incorporated by way of the engine mountings, their thickness being not less than the diameter of the holding down bolts.

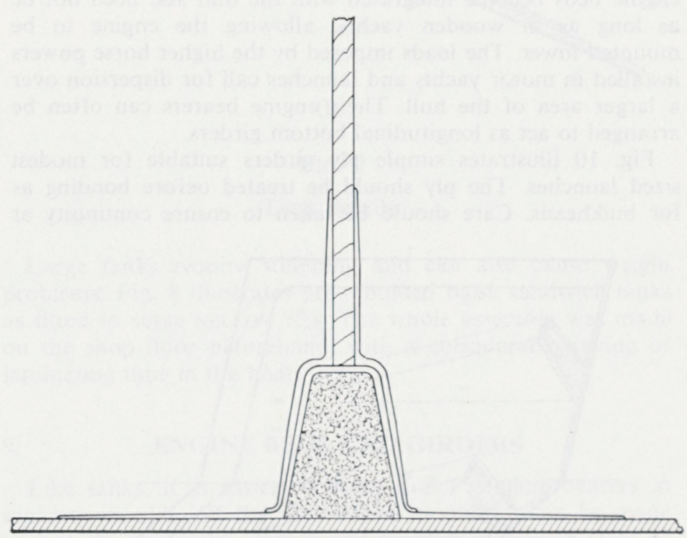


FIG. 12(a)

Ply floor.

10. FLOORS

Satisfactory floors can be made from either ply bonded-in similarly to bulkheads, or laminated in G.R.P. over foam cores (Figs. 12(a) and 12(b)). Flanged floors are more difficult to produce for the same reasons as flanged girders. It is generally more economical to fit foam cores than G.R.P. pre-forms. The choice between timber and G.R.P. often depends on the number of floors required in relation to the amount of work of a similar nature in the particular boat.

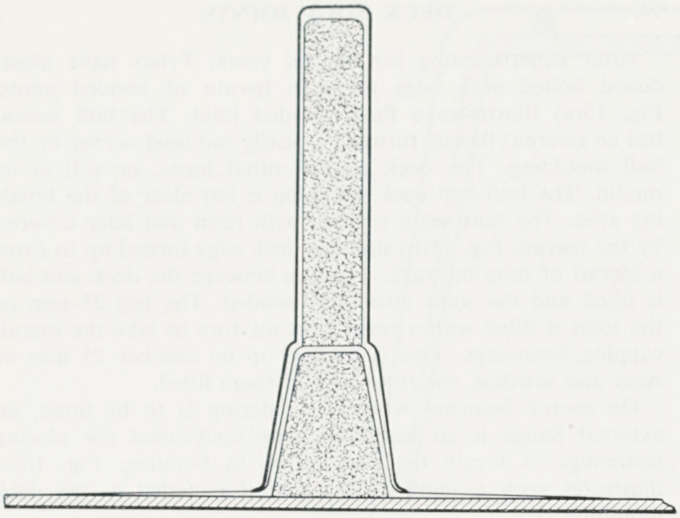


Fig. 12(b)

G.R.P. floor.

11. LIMBER HOLES

Adequate limber holes and drainage are very desirable features. Limber holes through ply bulkheads, floors and girders can be neatly cut after bonding with a tank cutter (Fig. 13(a)). The ply and bonding laminate should then be sealed with resin.

Limber holes through transverse frames and girders are more difficult. One of the best methods is to laminate G.R.P. tubes 100–150 mm (4–6 in) longer than the frame width onto the hull in the required positions. The frame, or girder core is then cut over them and laminated-in normally (Fig. 13(b)). The diameter of the limber holes should not exceed a third of the depth of the frame. Another method, using a strip of sheet, is particularly suitable for floor to girder, or floor to tank connections (Fig. 13(c)).

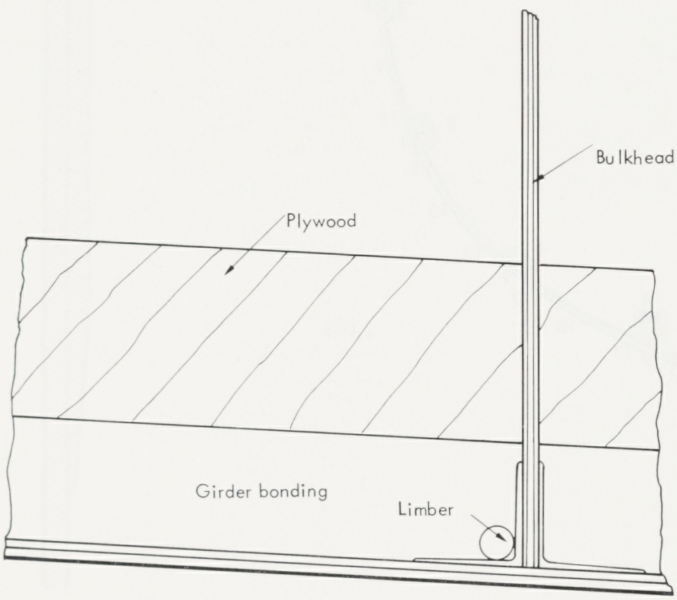


Fig. 13(a)

Limber hole cut through ply and bonding.

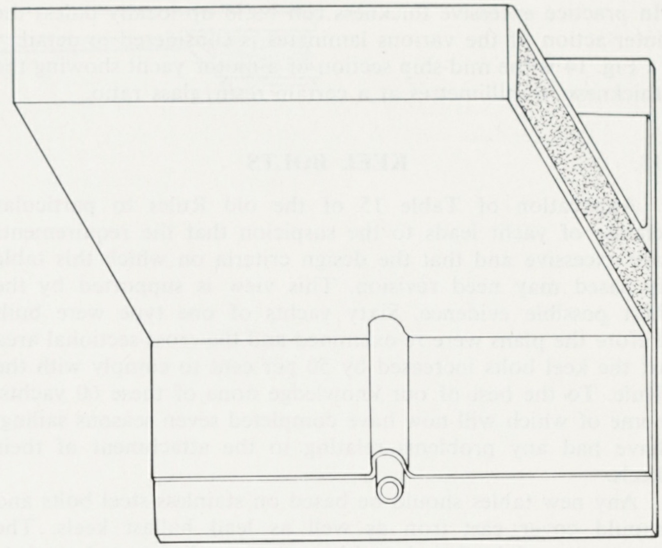


Fig. 13(b)

G.R.P. tube limber through foam cored girder.

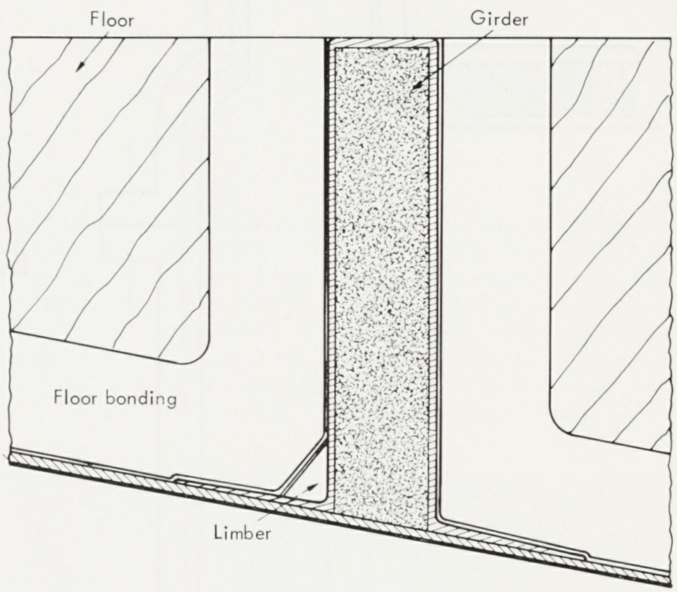


Fig. 13(c)

G.R.P. sheet limber through ply floor at girder connection.

12. OVERALL WEIGHT AND THICKNESS OF HULL STRUCTURE

Having separately considered the scantlings of shell framing, girders and tanks, deck edge joint and any other reinforcement, it may be advisable to check on the combined effect.

In practice excessive thickness can build up locally unless the inter-action of the various laminates is considered in detail.

Fig. 14 is the mid-ship section of a motor yacht showing the thickness in millimetres at a certain resin/glass ratio.

13. KEEL BOLTS

Application of Table 15 of the old Rules to particular classes of yacht leads to the suspicion that the requirements are excessive and that the design criteria on which this table is based may need revision. This view is supported by the best possible evidence. Sixty yachts of one type were built before the plans were re-examined and the cross-sectional area of the keel bolts increased by 50 per cent to comply with the Rule. To the best of our knowledge none of these 60 yachts, some of which will now have completed seven seasons sailing, have had any problems relating to the attachment of their keels.

Any new tables should be based on stainless steel bolts and should cover cast iron as well as lead ballast keels. The proportion of depth to breadth needs extending to at least 6 : 1, though it is a little obscure how the breadth of a streamlined keel is measured.

A large proportion of external ballast keels will have some bolts off centreline and it is questionable, whether simple tables of this sort are of much practical value.

14. DECK EDGE JOINTS

After experimenting for several years, Tylers have abandoned bolted deck edge joints in favour of bonded joints. Fig. 15(a) illustrates a flush bonded joint. The hull mould has an internal flange, forming a neatly radiused corner on the hull moulding. The deck can be fitted loose, or still in its mould. The hull and deck stiffening is left clear of the bonding area. The butt seam is filled with resin and later covered by the toerail. Fig. 15(b) shows a deck edge turned up to form a toerail or mini-bulwark. The gap between the deck and hull is filled and the joint internally bonded. The top 25 mm of the joint is filled with a resin glass mixture to take the toerail capping fastenings. This is backed up by another 25 mm of resin and sawdust, the remainder is foam filled.

On motor launches where a fendering is to be fitted, an external flange is an asset and very convenient for placing fastenings to locate the deck prior to bonding. Fig. 15(c) illustrates such a joint with a toerail included in the deck moulding.

There are many other designs of deck edge joint, but these three simple ways of making this very important connection have been well tried and proved reliable in production and service.

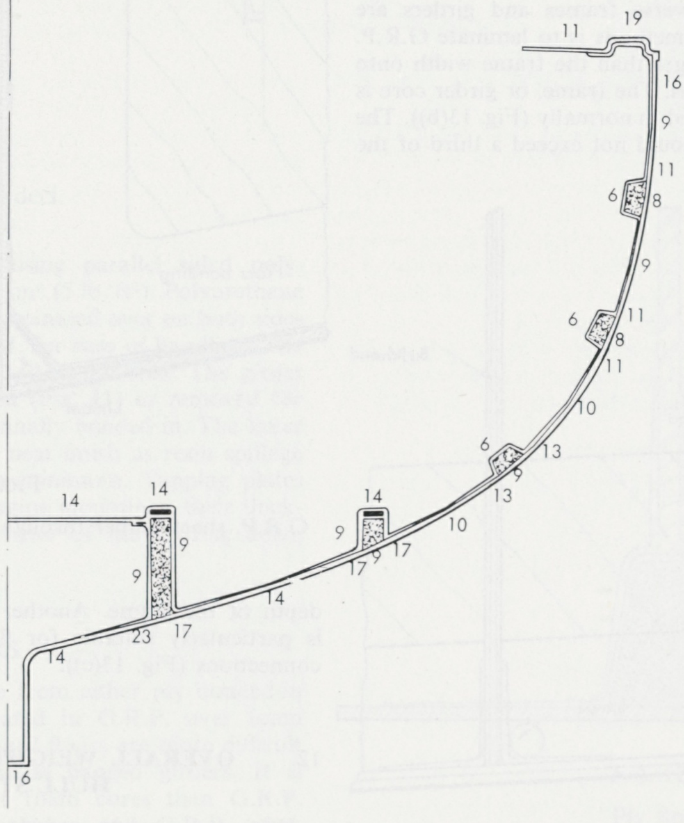


FIG. 14

Mid-ship section showing thickness in millimetres.

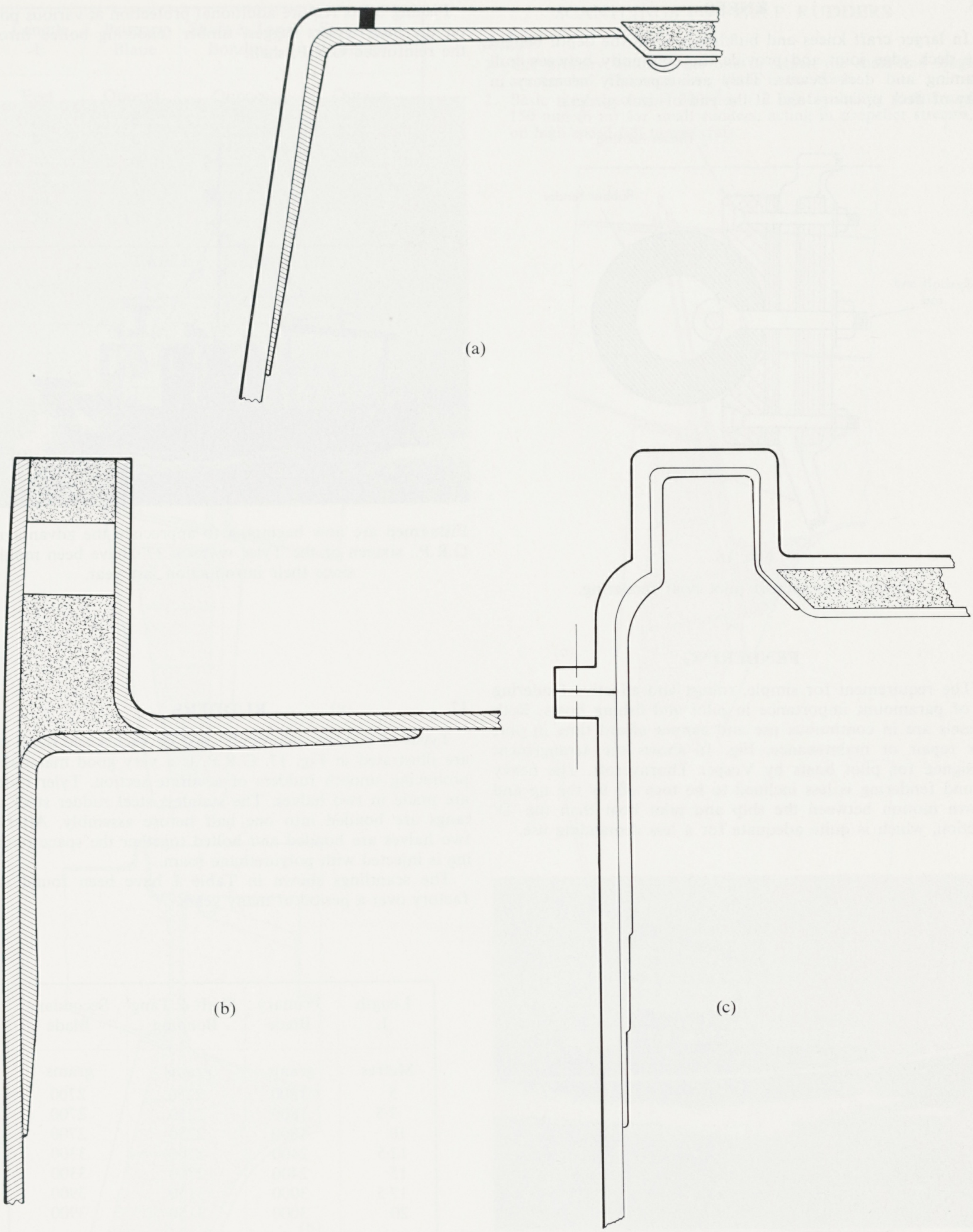


FIG. 15
Deck edge joints.

15. KNEES

In larger craft knees and bulkheads form the depth behind the deck edge joint and provide the continuity between hull framing and deck beams. They are especially necessary in way of deck openings and at the end of deck girders.

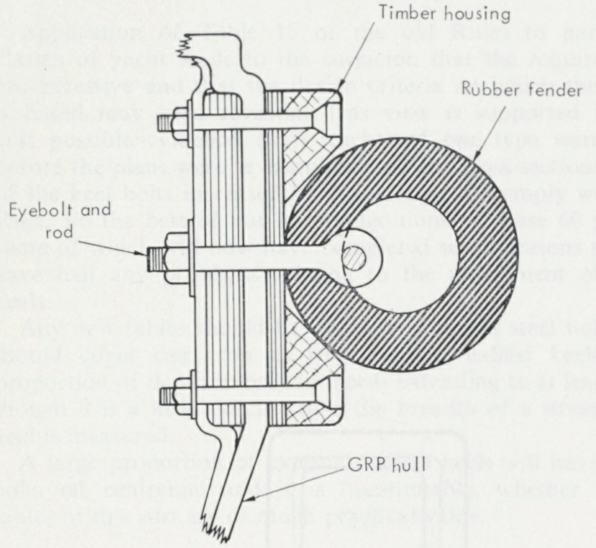


FIG. 16

Vosper Thornycroft pilot boat fendering.

16. FENDERING

The requirement for simple, robust and effective fendering is of paramount importance in pilot and fishing boats. Both vessels are in continuous use and cannot afford time in port for repair or maintenance. Fig. 16 shows the arrangement designed for pilot boats by Vosper Thornycroft. The heavy round fendering is less inclined to be torn off by the up and down motion between the ship and pilot boat than the 'D' section, which is quite adequate for a less demanding use.

'Gantock' a NELSON 60 pilot boat completed to Class by Alexander Robertson for the Clyde Pilotage Authority.

Fishing boats require additional protection at various points on the hull; Tylers suggest timber fendering bolted through the reinforced G.R.P. shell.

Fishermen are now beginning to appreciate the advantage of G.R.P., sixteen of the Tyler WATSON 37's have been moulded since their introduction last year.

17. RUDDERS

Types of rudders commonly used on yachts and small craft are illustrated in Fig. 17. G.R.P. is a very good material for producing smooth rudders of accurate section. Tyler rudders are made in two halves. The stainless steel rudder stock and tangs are bonded into one half before assembly. After the two halves are bonded and bolted together the space remaining is injected with polyurethane foam.

The scantlings shown in Table 1 have been found satisfactory over a period of many years.

Length L	Primary Blade	Shaft & Tang Bonding	Secondary Blade
Metres	grams	grams	grams
5	1800	2250	2700
7·5	1800	2250	2700
10	1800	2250	2700
12·5	2400	2700	3300
15	2400	2700	3300
17·5	3000	3150	3900
20	3000	3150	3900

TABLE 1 (Metric)

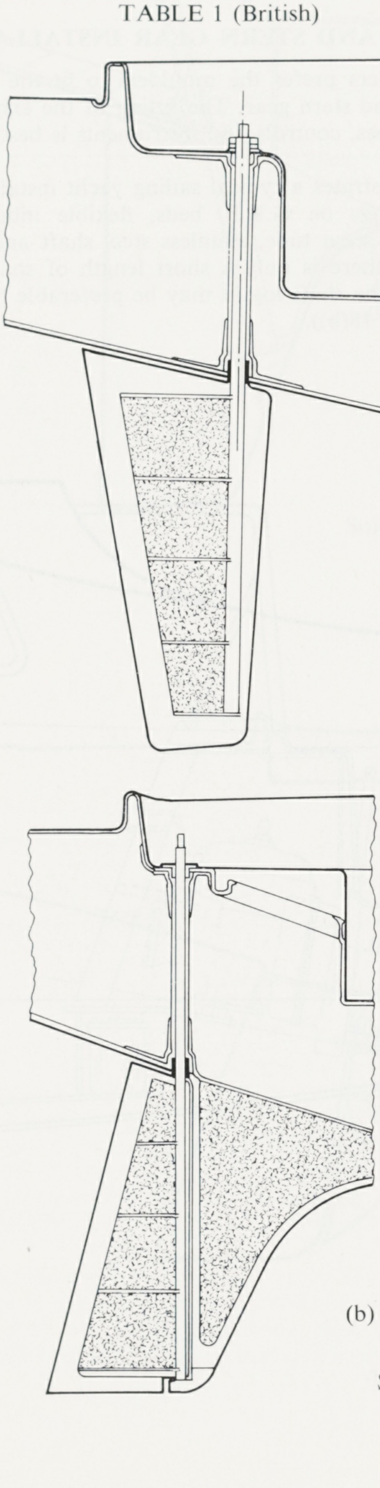
Length L	Primary Blade	Shaft & Tang Bonding	Secondary Blade
Feet	Ounces	Ounces	Ounces
20	6	$7\frac{1}{2}$	9
30	6	$7\frac{1}{2}$	9
40	8	9	11
50	8	9	11
60	10	$10\frac{1}{2}$	13
70	10	$10\frac{1}{2}$	13

TABLE 1 (British)

SCANTLINGS FOR G.R.P. RUDDERS

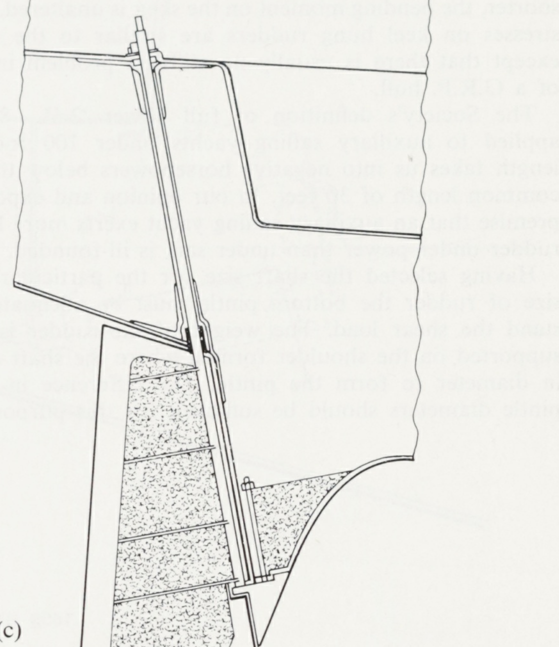
NOTES:

1. The primary blade is the one to which the shaft and tangs are bonded. The secondary blade is the cover.
2. Basic tang spacing is 300 mm (12 in) for sailing yachts and 150 mm (6 in) for small rudders, acting in propeller streams, on high speed full power craft.



(a)

(b)



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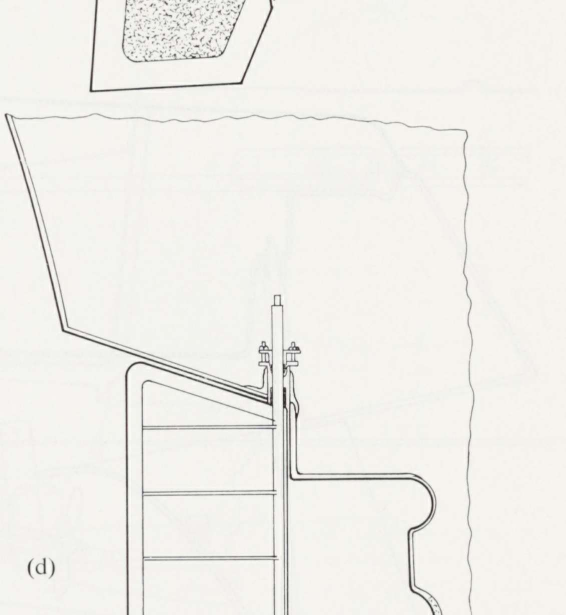

(d)

FIG. 17

Sailing yacht rudders in common use.

Shafts of spade rudders have to take the entire bending and twisting moments. The effect of a skeg is not only to move the centre of pressure forward and reduce the twisting moment, but also the bending moment is reduced four-fold by virtue of the bottom bearing. This substantial reduction of shaft bending moment will only be achieved if the skeg is stiffer than the rudder shaft. As most skegs are made of G.R.P., they usually require substantial reinforcement to meet this criteria.

Although the skeg in a partly balanced skeg rudder is shorter, the bending moment on the skeg is unaltered. The shaft stresses on keel hung rudders are similar to the skeg type. except that there is usually no stiffness problem in this part of a G.R.P. hull.

The Society's definition of full power '2·6L—80 h.p.' as applied to auxiliary sailing yachts under 100 foot Lloyd's length takes us into negative horsepowers below the not uncommon length of 30 feet. In our opinion and experience the premise that an auxiliary sailing yacht exerts more load on its rudder under power than under sail, is ill-founded.

Having selected the shaft size for the particular type and size of rudder the bottom pintle must be adequate to withstand the shear load. The weight of the rudder is normally supported on the shoulder formed where the shaft is reduced in diameter to form the pintle. The difference in shaft and pintle diameters should be sufficient for this purpose.

18. CENTREBOARDS

One advantage of building in G.R.P. is the comparative ease with which a centreboard case can be made as part of the hull moulding. The centreboard itself can be made of galvanised steel, bronze or G.R.P. A G.R.P. board can be made to an accurate streamlined section with strength and finish compatible with a G.R.P. yacht.

Tylers make G.R.P. centreboards in a similar way to rudders. A mild steel plate is securely bonded into one half before the two halves are bolted and bonded together.

19. ENGINE AND STERN GEAR INSTALLATION

Many customers prefer the moulders to fit the stern gear, or the engine and stern gear. The fitting of the exhaust, cooling and fuel pipes, controls and instruments is best left to the finishing yard.

Fig. 18(a) illustrates a typical sailing yacht installation with flexible mountings on G.R.P. beds, flexible inboard gland bearing, bronze stern tube, stainless steel shaft and propeller bracket. When there is only a short length of shaft between the engine and the shaft log, it may be preferable to use solid mountings (Fig. 18(b)).

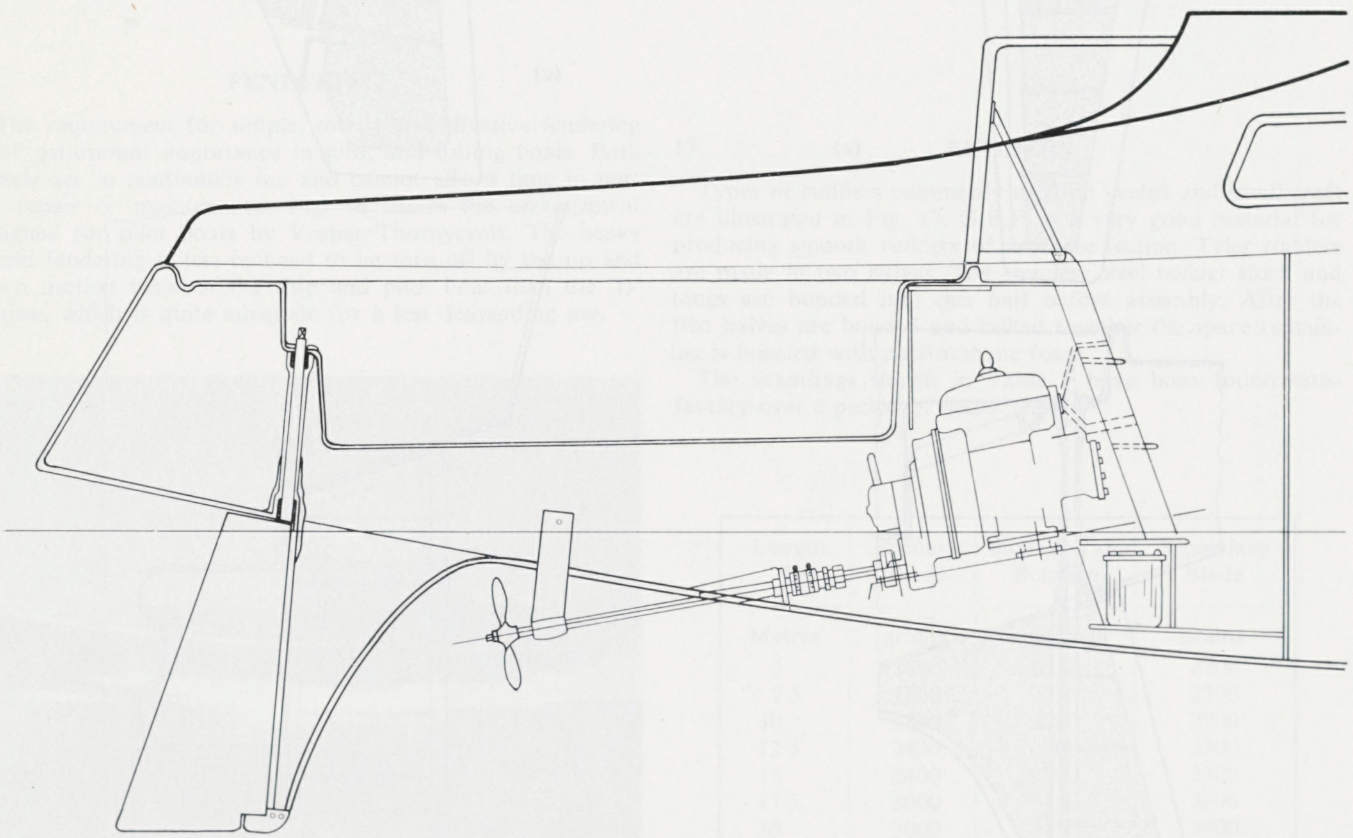

Fig. 18(a)

Flexibly mounted engine and stern gear.

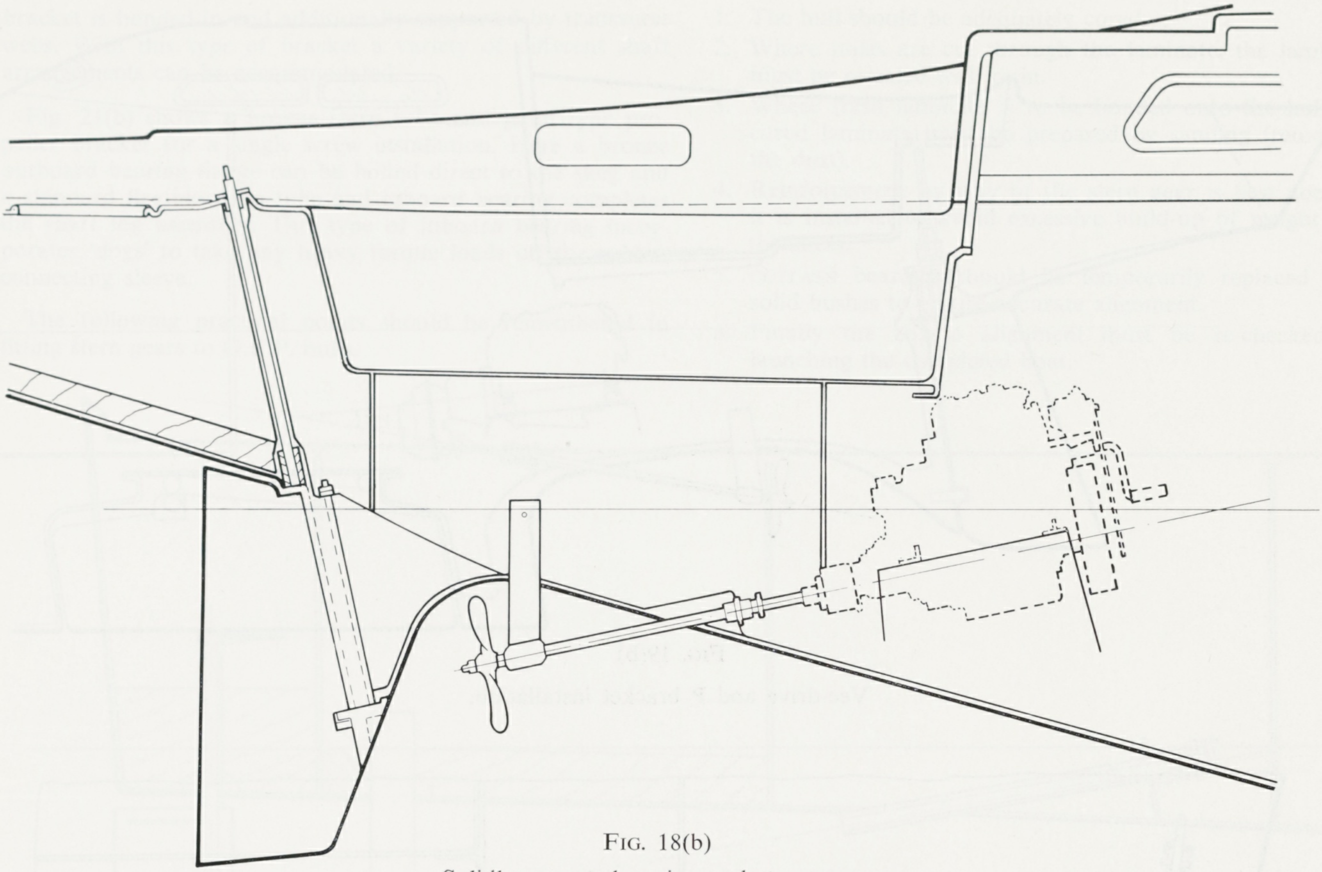

FIG. 18(b)
Solidly mounted engine and stern gear.

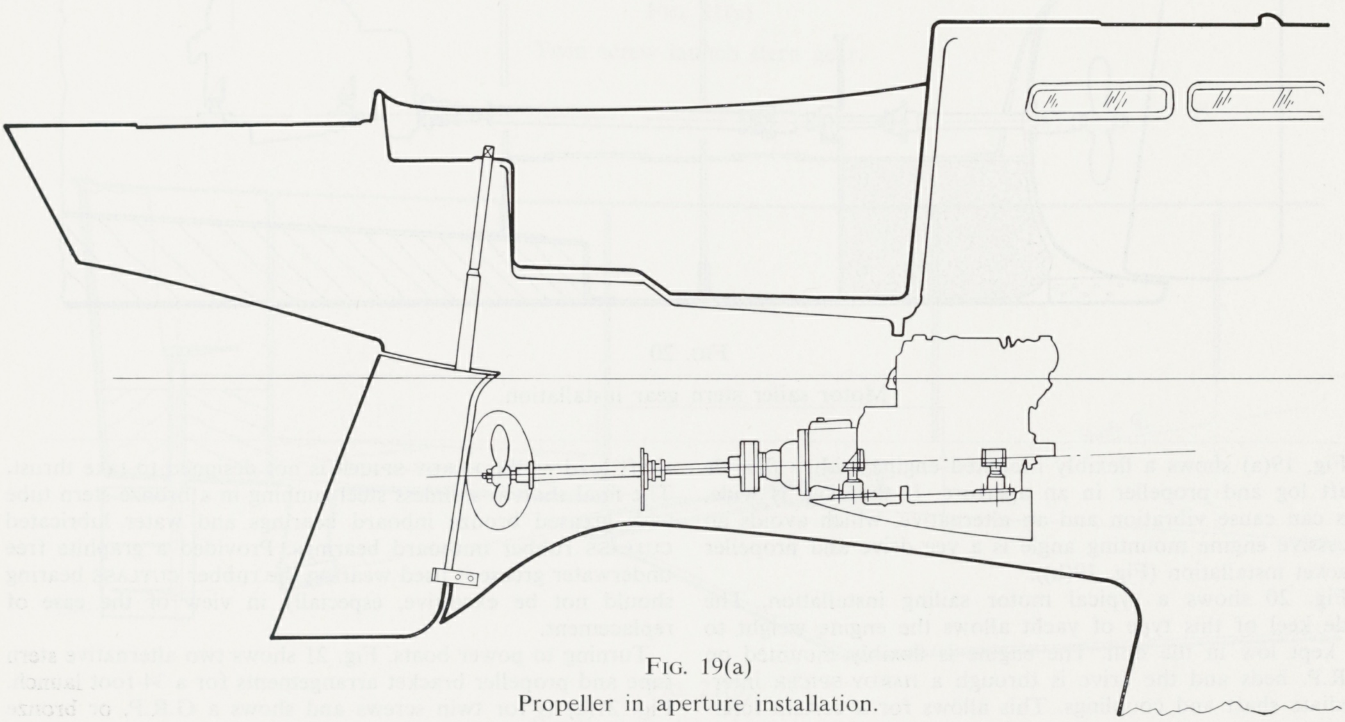

FIG. 19(a)
Propeller in aperture installation.

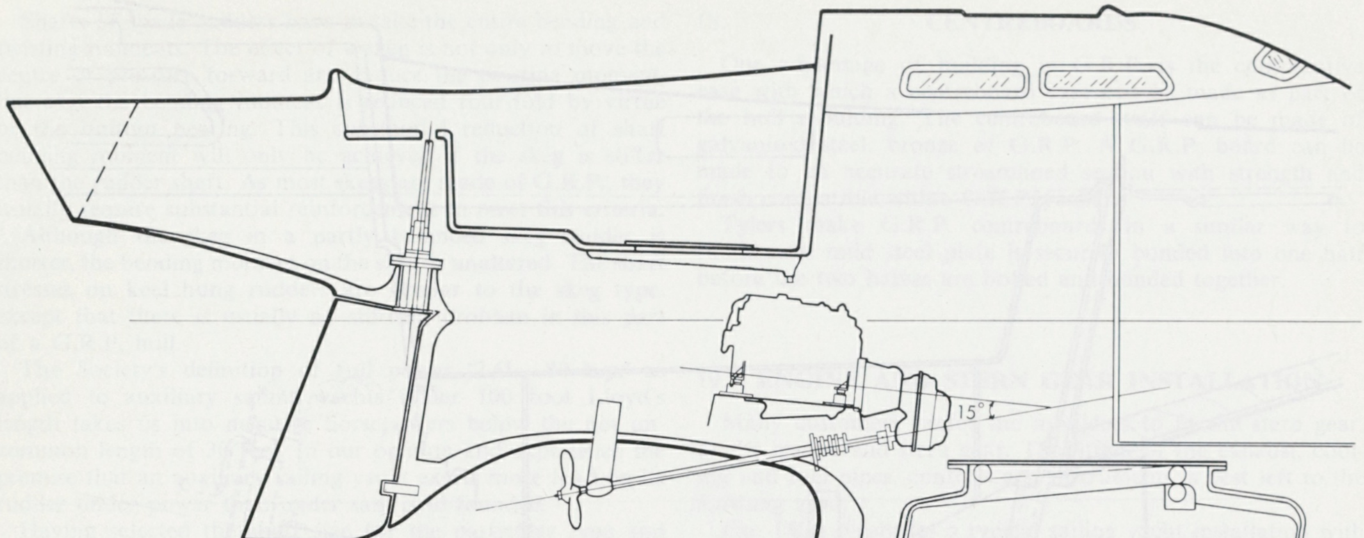

FIG. 19(b)

Vee-drive and P bracket installation.

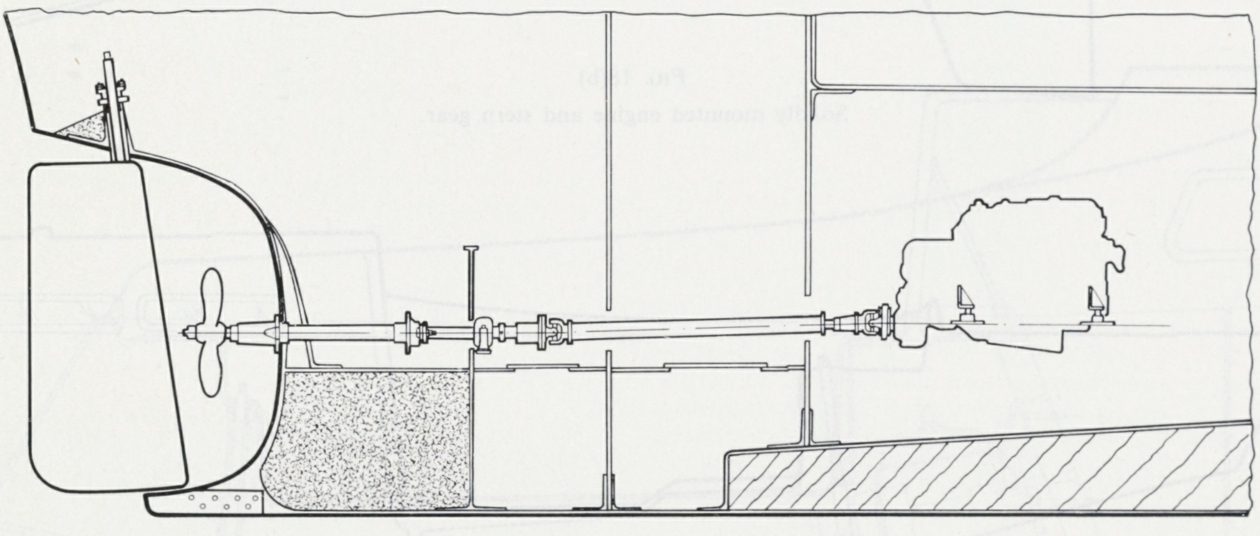

FIG. 20

Motor sailer stern gear installation.

Fig. 19(a) shows a flexibly mounted engine with a flexible shaft log and propeller in an aperture. If the skeg is wide, this can cause vibration and an alternative, which avoids an excessive engine mounting angle is a vee drive and propeller bracket installation (Fig. 19(b)).

Fig. 20 shows a typical motor sailing installation. The wide keel of this type of yacht allows the engine weight to be kept low in the hull. The engine is flexibly mounted on G.R.P. beds and the drive is through a HARDY-SPICER intermediate shaft and couplings. This allows for a certain tolerance in engine alignment. A thrust bearing takes the propeller shaft load as the HARDY-SPICER is not designed to take thrust. The final shaft is stainless steel running in a bronze stern tube with greased bronze inboard bearings and water lubricated CUTLASS rubber outboard bearings. Provided a graphite free underwater grease is used wear on the rubber CUTLASS bearing should not be excessive, especially in view of the ease of replacement.

Turning to power boats, Fig. 21 shows two alternative stern tube and propeller bracket arrangements for a 34-foot launch. Fig. 21(a) is for twin screws and shows a G.R.P. or bronze stern tube and a through hull propeller bracket. The propeller

bracket is bonded-in and additionally supported by transverse webs. With this type of bracket a variety of different shaft arrangements can be accommodated.

Fig. 21(b) shows a bronze stern tube and palm type propeller bracket for a single screw installation. Here a bronze outboard bearing flange can be bolted direct to the skeg and a standard flexible stern tube and inboard bearing completes the shaft log assembly. This type of inboard bearing incorporates 'dogs' to take any heavy torque loads off the rubber connecting sleeve.

The following practical points should be remembered in fitting stern gears to G.R.P. hulls.

1. The hull should be adequately cured.
2. Where holes are cut through the laminate, the laminate must be resealed with resin.
3. Where fresh laminate is to be bonded onto the hull the cured laminate must be prepared by sanding (removing the dust).
4. Reinforcement by way of the stern gear is best done as it is installed to avoid excessive build-up of weight and thickness.
5. CUTLASS bearings should be temporarily replaced with solid bushes to ensure accurate alignment.
6. Finally the engine alignment must be re-checked on launching the completed boat.

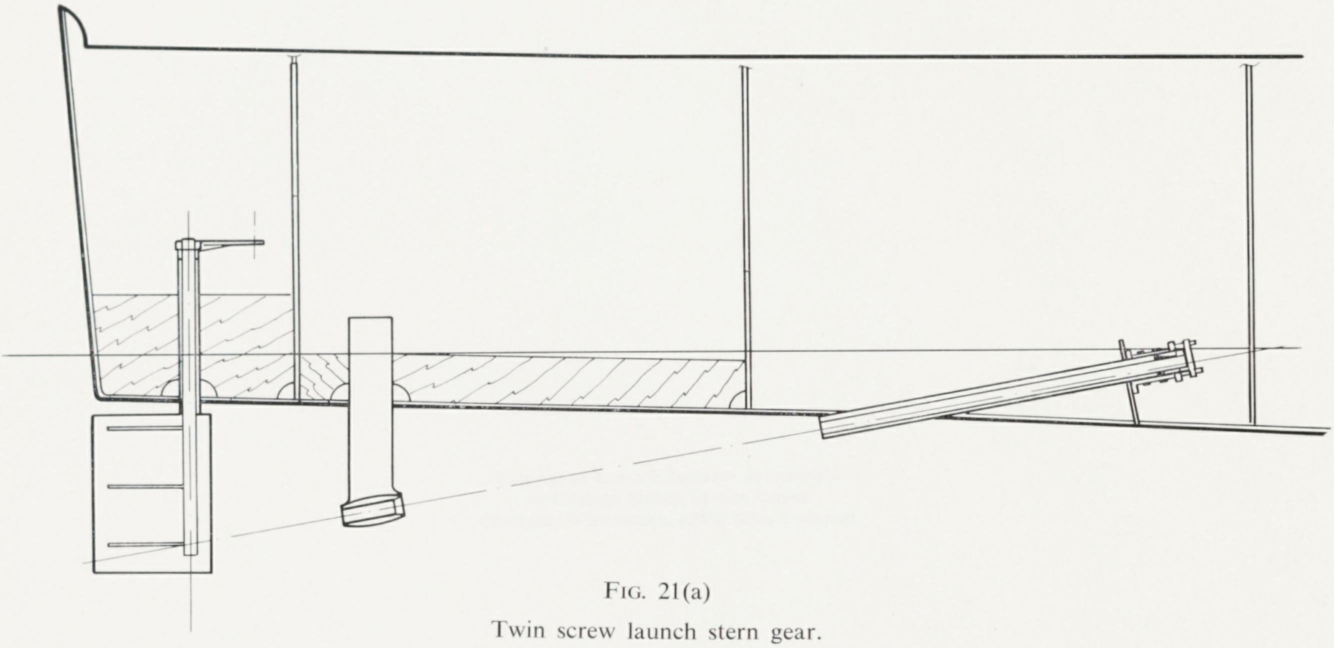

FIG. 21(a)
Twin screw launch stern gear.

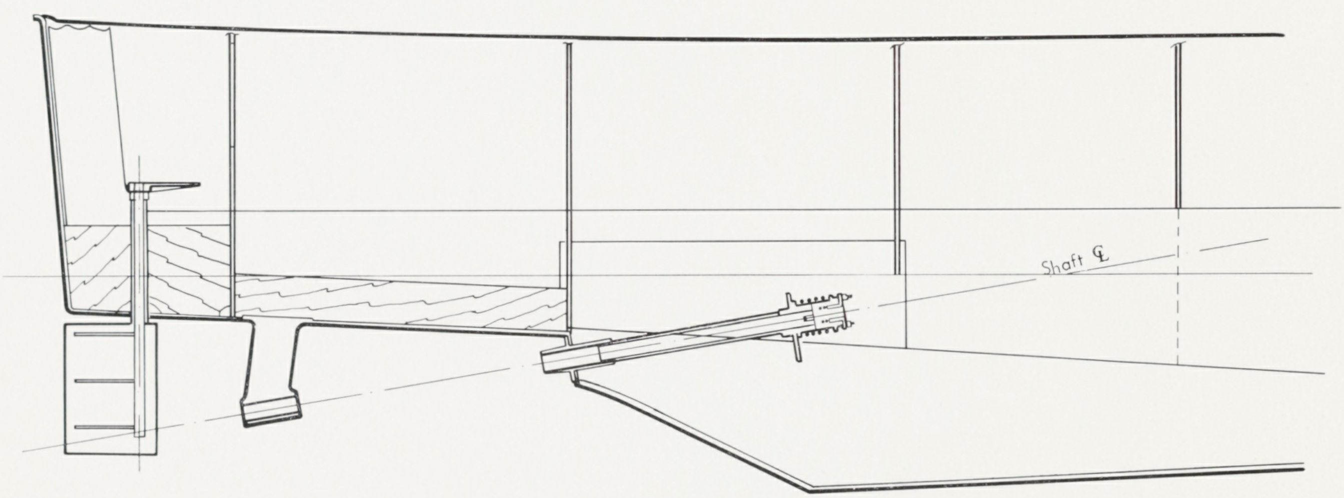

FIG. 21(b)
Single screw launch stern gear.

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Discussion

on

Messrs. J. Tyler and R. Muster's Paper

SOME PRACTICAL ASPECTS OF MOULDING G.R.P. YACHTS AND SMALL CRAFT

Paper No. 4. Session 1974-75

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Discussion on Messrs. J. Tyler and R. Muster's Paper

SOME PRACTICAL ASPECTS OF MOULDING G.R.P. YACHTS AND SMALL CRAFT

Mr. R. J. DUNN

I feel duty bound to express the Association's appreciation for the excellent paper the Authors have given.

In business today and particularly at this time of the year, orders are garnered and searched for and consequently it is with gratification for their efforts under such pressures that I open the discussion.

In referring to the paper, there are several points that I would like to ask the Authors.

Resin/Glass Ratio, Mat Laminates

Flexural strength, sheer strength and tensile strength, all surely are somewhat related to the viscosity and quality of the resin, also the temperature at the time of laminating. Would the Authors not agree that by using thin resin and endeavouring to exclude air, that one would ultimately arrive at a lighter boat, and a boat that would be less flexible than desired and more brittle. This could prove to be quite serious. Would they not wish to see increased control and acceptance of quality resin? In supporting such an approach the Authors would surely agree that when G.R.P. moulds are finally destroyed, having been made with a high glass content, it is tremendously difficult to break the mould into small pieces.

In Section 3 the Authors appear to answer two of the three items. The one on which I should like to draw them, is high heat distortion temperature. Have the Authors now any positive figures on the movement or distortion of a boat that has for some period of time, say six months, been subject to high ambient temperatures whilst at anchorage in some extremely hot climate? Few manufacturers take heed of this factor which could result in stressed points in the structure.

On the subject of shell laminate the Authors state that clear gelcoats are now accepted as having the best water resistant properties. It is presumed that internally in way of the bilges a protective coating is applied. Is the subject of the penultimate paragraph of this section aimed at increasing the manœuvrability and speed of the craft?

In the case of blisters or an entrainment, what do the Authors suggest as remedial action, especially in underwater areas and particularly when the craft is new or within its guarantee period?

Would they agree that, above water, it would be sufficient to sand-off and apply two gelcoats, and below the waterline to add two coats of polyurethane.

Mr. R. RYMILL

The Authors are to be complimented on a most interesting and informative paper. There are, however, a few small points of some importance that require correcting.

2. **Resin/glass ratios**

2.1 Flexural strength: While it is true to say that a 2·5: 1 resin/glass ratio produces a laminate capable of withstanding a higher load as compared to the same weight of reinforcement laminated at a lower rate of 1·5: 1, the increase is only about 50 per cent and not double as the Authors have stated.

2.3 Tensile strength: Here the Authors refer to 'tensile strengths', whereas it is assumed that the 'capability of withstanding tensile loads' was intended. A C.S.M. laminate at a resin/glass ratio of 2·5: 1 has, in fact, a higher load bearing capability than a woven roving laminate at 1: 1 with an equal weight of glass reinforcement.

The effects of resin/glass ratios on moduli are often as important as their effects on strength.

Another important aspect of the physical properties of G.R.P. which is all too frequently ignored is that of scatter, which is considerable for this material. A statistical approach to the design properties of G.R.P. is a field that would merit investigation.

4. **Shell laminate**

(a) The actual clear panel area between stiffeners is normally used in calculations carried out by the Society.

(b) The combined thickness of laminates is also taken into consideration in calculations, providing they are indicated on the drawing.

The effect of this additional reinforcement can vary depending upon the proportion it extends over the panel and the actual stiffener form and configuration.

i.e. Edges Held and Fixed—maximum stress at centre of long edges.

Edges Held *not* Fixed—maximum stress at centre of panel.

5. **Framing and Stiffeners**

(a) With the increase in allowable stress, there is approximately a 7 per cent reduction in section modulus, which has already been incorporated in the provisional Rules for fishing craft.

(b) The properties of uni-directional roving vary considerably depending upon their application.

When used in the crown of stiffeners the Society calculate the equivalent C.S.M. area on the basis of a tensile modulus of $2{\cdot}3\times10^6$ lb/in^2 as opposed to the 2×10^6 lb/in^2 for woven rovings.

(c) For larger craft there is an argument for longitudinal framing supported at web frames and bulkheads, as a constant depth transverse frame in conjunction with longitudinals is wasteful in both material and labour, since the longitudinals act only as panel stiffeners.

Bulkhead Connections: In high speed craft bulkheads should be landed on foam to provide flexibility at the support and reduce the stress locally.

Limber Holes: All limber holes should generally be made from sections of semi-circular G.R.P. tube bonded into position before fitting the stiffener, since the methods of either cutting them afterwards—especially those through plywood—or the fitting of a complete tube, can cause problems from unsatisfactory sealing, difficulty with bonding in and total drainage respectively. Also by using pre-moulded G.R.P. semi-circular sections one may compensate for the loss of material in the web of the stiffener.

Keel Bolts: The table in the provisional G.R.P. Rules is the one which the Society has used in wood and composite vessels for a considerable number of years without any trouble. However, this table and further requirements will be examined with the present revision of the G.R.P. Rules.

Deck Edge Joints: The Society would prefer to see a micro-balloon mix used for non-structural filling as opposed to the old method of sawdust and resin.

Rudders: The Authors have misinterpreted the provisional G.R.P. Rules in assuming that the Rules are based on 'the premise that an auxiliary sailing yacht exerts more load on its rudder, under power than under sail'. The not unreasonable premise on which the clause (2702) in the provisional G.R.P. Rules is based is that when the total b.h.p. exceeds a certain amount the rudder stock shall be sized by considering the speed of the yacht and the rudder geometry. The Authors are probably correct in arguing that, with the trend to higher powered auxiliaries, the dividing line of horse power might require re-drafting; but the effect of this clause in requiring even relatively low powered auxiliary yachts' rudders to be considered on a speed and rudder geometry basis is by no means unrealistic.

Mr. C. Beason

I would like to pass a few comments on the engines and sterngear installations described and illustrated in the paper.

With reference to the chapter on engine beds and girders, would the Authors care to go into a little more detail, by stating what procedure is used for finishing the top surface of the engine seats in way of the engine feet shown in Fig. 7 and Fig. 11. Perhaps additional metallic plates are wetted in place?

Considering Fig. 18(a) and (b) showing typical sailing yacht installations. The Authors' suggestions that when only a short length of shaft between the engine and shaft log exists it may be preferable to use solid mounting in lieu of a flexible stern gland is not strictly correct. The adoption of the flexible stern gland came about, to the best of my knowledge, when the distance between the stern gland and engine output coupling was insufficient to accommodate a suitable arrangement of flexible couplings with resilient-mounted engines. With the fitting of only one flexible coupling, the movement over the short length of screw shaft penetrating into the yacht was such that it was nearly impossible to keep the packing in the stern gland watertight. Whilst on the matter of flexible stern glands, I would like to say that the Society restricts this design to shafts not greater than 70 mm ($2\frac{3}{4}$ in) diameter. These glands may take two forms, those where torque due to friction in the gland can be transmitted into the flexible sleeve, and those which have a suitable device to restrict the angular movement to prevent this. The former of these glands, where there is no restricting device, is made a subject of class, the flexible sleeve being renewed at each Biennial Survey.

It is a pity the Authors did not show more details in their sketches of the construction of the stern tubes and the method of securing them into the hull. With today's practice of turning away from the usual metallic shaft log and stern tube carried over from wood yacht construction, great attention should be paid to this point. Builders sometimes fabricate the tube from G.R.P. using a thin bronze tube as a former. With this type of construction the tube should be of adequate thickness, bearing in mind that a robust connection has to be made to accommodate the stuffing box and flange for gland securing studs. If a flexible gland is to be fitted then the tube should be of adequate thickness to resist compression due to pressure of the flexible sleeve securing clamps. When a tube of this type is fabricated it should be checked for concentricity and straightness, and the degree of bonding of the G.R.P. to the tube before installing in the hull. The securing of the stern tube in G.R.P. yachts is of prime importance remembering that a connection similar to that used in yachts constructed of wood or steel is required, where the sternframe in steel yachts (or the deadwood in wood yachts) is bored such that the tube is a draw fit and supported in way of the bushes, then secured aft with a tube nut or deadwood plate, and secured inboard at the gland housing with bolts or coach bolts.

Fig. 20 indicates a standard type of stern tube that could be fitted in a yacht constructed either of wood or steel. Here it is not clear how the tube is secured. It is concluded that a suitable structure has been provided integral to the yacht in way of the after housing and in which a metallic plate has been incorporated of a thickness to accommodate the studs securing it. A similar method has been presumed for securing the fore end of the tube, and that the whole length of the tube is then supported in a fabricated structure similar to a shaft log in a wood yacht, or that fabricated floors at not too large a spacing are bonded to the tube and surrounding yacht structure.

I agree with the Authors that it is necessary to fit a thrust bearing so that the propeller thrust is not transmitted by the Hardy-Spicer coupling. At the moment there are two schools of thought on this, with some builders inclined to think that these type of couplings can transmit thrust. This being so, the life of the needle bearings in the Hook's joint would be greatly impaired. I am not certain that these type of couplings allow a certain tolerance in engine alignment, my own experience is that to be certain of trouble-free running the alignment of this type of coupling and of any other flexible coupling for that matter, should be as accurate as that for a fixed installation. It must also be remembered that any variation in the angle between the Hardy-Spicer couplings and the input and output shafts would produce a varying angular velocity and therefore a fluctuating torque, which could produce a greater stress in the shaft than anticipated.

I'm afraid I cannot agree with the idea of having a grease lubricated inboard bearing and a water lubricated rubber outboard bearing. I think it will be found that over zealous yacht owners pump grease into the tube which sooner or later reaches the rubber bearing, picking up silt or sand from the water lubricated aft bearing and producing rapid wear and sometimes destruction at the rubber bearing.

With reference to Figs. 21(a) and (b) I think that my remarks concerning the securing of the tubes would also apply.

I would like to complete by thanking the Authors for a very interesting paper and would add that as far as alignment of shafting and engines in the type of craft under consideration is concerned too much care cannot be taken. I conclude that reference to Cutlass bearings being temporarily replaced with solid bushes is to facilitate the use of piano wire, and not a shaft as the distances to be spanned indicate there may be some sag in the shaft.

Mr. K. J. Fryer

I would like to extend a welcome to the Authors and to compliment them on the quality of the drawings contained in the paper.

Referring to paragraph 17—'Rudders' it is considered that even if the skeg is made strong enough to be considered a support to the rudder stock the weight of the blade and stock should be taken by the inboard structure of the boat which is normal on all ships. Certainly in the case of the 'spade' type rudder the weight has to be taken inboard.

When filling void spaces, have the Authors any experience of materials other than foam?

To the Surveyors quality control is all important, and it would be appreciated if some indication of the degree of control exercised would be given, and what facilities are made available to the Surveyors.

It is not possible to tell by merely looking at a G.R.P. hull whether its thickness is correct, and that the prescribed number of reinforcing mats have been used. It is necessary for the Surveyors to check both the materials and construction of the vessel with the detailed plan approved by the Society.

As a matter of interest, it is known that in at least one Scandinavian boat builder's works it is practice to drill small holes in the most important parts of the structure in order to measure its thickness. How would the Authors verify the details given in Fig. 14?

Mr. P. J. Wickham

I would like to thank the Authors for presenting a paper which contains a wide range of information invaluable to the moulding industry and to the yacht designer alike.

The rapid increases in the world prices of the basic ingredients necessary for the production of a G.R.P. structure has made it increasingly more important that the moulder and the designer make the most ecomonic use of the available materials, more so perhaps than they have in the past. Uni-directional and woven rovings interwoven with carbon fibre (for example) in a short space of time will no doubt become more of an economic proposition. It is because economics are playing a far greater part in the industry than before that some of my questions are orientated in this direction.

One obvious reduction in the materials of resin and glass can be achieved using a form of sandwich construction, such as the 'Tyton' shown in the paper. A 25 mm single laminate can be replaced by a sandwich consisting of outer skins of 1·5 mm and P.V.C. foam core of 40 mm or outer skins of 3 mm and a core 25 mm for equivalent longitudinal stiffness. In this context, bearing in mind that the foam sandwich construction has lower bending stiffness and compressive strength than a single skin I would like to ask the Authors if they feel that any overall saving in material and labour costs can therefore be achieved by substituting the sandwich for the single skin?

From the paper it appears that the majority of 'infill' material is P.V.C. foam. Do the Authors therefore consider that the use of other materials like paper and cardboard particularly for forming stiffening members are not value for money?

In order to make better use of the properties of resin and mat it is important, when designing structures to finer limits, that the resin/glass ratio must be accurately maintained. In general the quality of contact moulding using the hand lay-up method is variable due to the human element and the strengths are relatively low. Therefore to maintain better controls on the resin/glass ratio other methods of moulding—injection, vacuum/pressure bag, etc., either used singularly or in combination could be adapted. If the resin/glass ratio is maintained at near the optimum of around 2·25 : 1 do the Authors think the reduction in materials so obtained would offset the possible extra expenditure in a more precise lay-up method on a series production? Perhaps TYLERS have considered using moulding methods other than contact moulding especially for the one-off moulding.

Resin

One might add to your list of particular qualities required for a good quality isophthalic gelcoat, a further quality, namely, lasting appearance. This quality applies especially to the yacht industry where no owner envisages painting his new yacht (apart from anti-fouling) after one season, particularly when nearly all 'sales patter' is centred around maintenance savings.

Clear gelcoats, as it has been stated, have been found to have the best water resistance properties. Their use below the waterline has also the added advantage that this load-bearing portion of the hull can readily be inspected for voids, excessive air inclusion, etc., so maintaining a tighter quality control and more uniform strength distribution.

Quality control in G.R.P. Structures is a serious problem since the material is made up progressively with each layer. There is not at present, as far as I am aware, a really effective method of non-destructive testing available. I would be grateful if the Authors could outline briefly the methods used at TYLERS in conjunction with the quality control of their mouldings.

Framing and stiffening

The use of wide base 'top-hat' sections for stiffening a thin shell can introduce distortion due to the contraction of the member whilst it is curing. For optimum strength, the laying up of the 'top-hat' stiffener should be done during or soon after the moulding, before the main moulding has cured. In this case the light moulding must be supported or braced to prevent this distortion. In order to reduce the effects of the contraction of the stiffening member the light moulding can be left until it is cured before moulding in the stiffener. The slight reduction in strength of the bond can easily be accommodated within the normal factor of safety. At what stage of the cure do TYLERS mould in the stiffening members and what steps, if necessary, are taken to avoid distortion?

Engine and stern gear installations

The various installations arrangements shown in the paper have obviously proved satisfactory over the years. However, when fitting engine bearers one should bear in mind that, such relatively massive members introduce different flexing patterns and if not carefully tapered off into the hull can produce local stress concentrations in excess of those already produced by the engine. Since the moulded hull is a flexible structure I believe that it is sound practice to continue the engine bearers further aft to include the area of the stern tube and 'A' bracket. In so doing the momentary misalignment caused when the hull flexes underway (which it is impossible to correct) can be removed. Perhaps the Authors can give a little more information concerning any problems they have experienced with hull flexibility in this region.

I refer to the Authors' final list of practical points that should be remembered in fitting stern gears to G.R.P. hulls and in particular to the first point in which they state "The hull should be adequately cured". How long, in fact, after completing the hull laminations do the Authors consider the hull as being adequately cured?

Mr. B. K. Batten

During the course of discussion on this paper Mr. Tyler remarked upon the extent of hull distortion seen in some boats, particularly in hot climates. I should be interested to know if this is a common occurrence, and in fact is ageing distortion, to a greater or lesser degree, a feature of G.R.P. craft.

Whereas most engine-stern gear systems shown in the paper can accept a small amount of alignment change, the vee-drive installation (Fig. 19(b)) is particularly sensitive, and the Society have already been involved with gearing problems due to bad alignment on this type of installation.

The Authors' views on setting up these alignments would be appreciated.

Mr. G. R. May

The Authors are to be congratulated on presenting an interesting paper based on their practical experience over the past 13 years.

I would like to enlarge and comment on the following points as set out in the paper.

Section 4

Application of double gel system

When using this system of gel-coat application it is important to obtain the best possible adhesion of the two gel-coats and to ensure that the application of the second gel-coat be applied as soon as the first gel-coat reaches a 'tough dry' stage. When a second gel-coat is used the rate of application for each gel-coat should be reduced to 1–1½ oz per sq. ft. to obtain a total thickness of between 0·024 in–0·030 in. Owing to the difficulty in applying the second coat of the same colour it is advisable to brush coat the second coat at 90° to the first application to obtain an even second coat and thus control the overall thickness.

Shell laminate and stiffener laminate

As the shape of the stiffening member can vary considerably, the point made by the Authors regarding consideration being given to the use of the distance between stringers rather than to the centres as at present used in design criteria, could lead to weak shell areas in way of the stringer core material especially in way of the larger wide based stringers as used in some of the larger types of sailing and motor yachts.

Section 6

'Tyton' construction and sandwich construction

In both of these types of construction it is important to ensure that where skin fittings are to be attached to the shell, the core should be cut back and the edges completely sealed and overlaid to the inside of the outer shell laminate and a hardwood pad fitted to receive the skin fitting fastenings. This will prevent ingress of water to the core material in the event of a leak occurring in way of the skin fitting and its fastenings.

Section 11

Limber Holes

Fig. 13(a) of the paper shows a limber hole cut through the plywood and bonding at the root angle. Careful consideration should be given to the positioning of limber holes and the accessibility *in situ* to enable a hole to be cut without disturbing the surrounding shell laminate. It is considered advisable to situate the limber holes some 5–6 in away from the root corners of laminate connections; with the vessel in motion the amount of bilge water left between the limber hole and the corner connections will be negligible.

Mr. C. A. Bedford

From experience the fitting of thin wall bronze stern tubes with covering shroud (Fig. 21(a)) creates the hazard of a change of shape after curing. A recent survey revealed that the stern tube had bowed and became oval in shape after removal of the CUTLASS bearings thereby creating problems of mal-alignment.

The Authors' note regarding the fitting of temporary solid bushes in way of the CUTLASS bearings meets with agreement and would be an advantageous necessity, particularly if they were longer in length than the bearings themselves.

Mr. F. W. Cane

The Authors have presented an interesting paper, dealing with a variety of subjects; they should be congratulated on the precise manner of presentation and clear illustrations.

My comments are confined to two sections of the paper, the first refers to Section 14, Deck Edge Joints.

One of the major advantages of G.R.P. hulls over conventional wooden hulls is the reduction in the number of joints. The majority of yachts are moulded with two joints, one at the centreline and one at the deck edge. Some moulders have designed their hulls in a manner permitting release from a one-piece mould which enables them to eliminate the centreline joint.

The deck edge joint has proved the most troublesome in service. In addition to the stresses imposed during sailing, the deck edge connection is subjected to damage from collision and contact with quay walls and other craft, etc., during manœuvring and mooring operations. Careful design is necessary to ensure continuity of strength between the joined members and the minimisation of stress concentrations. Simplicity of joint and ease of access is also essential in order that the laminator can carry out the bonding of the joint efficiently. It is interesting to note that the Authors state that after years of research they have abandoned mechanically fastened joints, in favour of bonded joints. In my opinion, often a combination of bonded and mechanically fastened joints can be employed to advantage. From studying the joints illustrated in Figs. 15(c) and (b) it can be seen that use of mechanical fastenings improves the integrity of the structure.

When loads are applied to the deck and hull the resulting deflection causes a tendency for the deck and shell laminate to peel away from the reinforcing bonding. To minimise this problem it is essential that the bonding laminates are carried well beyond the join, are of adequate thickness to ensure rigidity and are well tapered at the ends to prevent sudden changes in laminate thickness which cause stress concentrations. Additionally, a through bolted toerail fitted over the

joint assists in resisting the peeling effect at the interface of reinforcement and hull and deck structures. In the join illustrated in Fig. 15(c) it can be seen that resistance to peeling action has been increased. In addition, provided they are properly designed and placed, the mechanical locating fastenings assist in minimising the peeling effect and prevent complete failure of the joint should the bond fail.

My second comment refers to Section 16—Fendering, in which the Authors state that the shape of round fendering renders it less likely to be torn off by the up and down motion between the ship and pilot boat than the 'D' section. It is agreed that the shape is preferable for the arduous task imposed, but, in addition, the method of fixing by eyebolt and rod, which retains the fender into a shaped seating formed by the timber housing, assists greatly in resisting the tendency for the fender to be sheared off. As no holes are drilled in the working face of the fender to place fastenings, which is the normal practice in fitting D fendering, this also assists in preventing the rubber fendering being torn off.

In conclusion I would like to thank the Authors for presenting this paper and providing us with the opportunity of discussing the various points contained therein.

AUTHORS' REPLIES

The Authors agree with Mr. DUNN that the viscosity and quality of resin has a most important bearing on the properties of the laminate. The use of very thin resins might appear highly desirable, but in practice can cause many problems on large structures. Drainage is often evident and the exclusion of air during curing can be difficult.

When such resins are used on boats, whose laminate has been designed on the basis of weight of glass reinforcement, the resulting laminate is too thin and lacks flexural and shear strength. In addition the laminate is noticeably more brittle. Laminates manufactured from combination woven and chopped strand mats with low resin/glass ratios have a greater tendency to delaminate. This practise is commonly used in the United States for cheapness of manufacture, but test results indicate that a very poor structure is created.

With regard to heat distortion, TYLERS have observed some distortion in dark coloured foam sandwich hulls operating in tropical climates. Resin suppliers have been influenced by market forces to produce resins of inferior quality which have an adverse effect on the quality and durability of the finished product. In the Authors' opinion the requirements for Lloyd's approval of resins for boat construction are not high enough.

Osmosis has fortunately been rare on TYLER hulls, largely due to the use of a good quality clear gel-coat below the waterline. The remedy is to thoroughly sand the hull and coat with two coats of two-part polyurethane. On the topsides four coats are recommended before burnishing to achieve a durable finish as good, or better than, the original. Now that there are a fair number of five and ten year old G.R.P. boats around, which may have become scratched or faded, it is becoming increasingly common to repaint them in this way. TYLERS have painted new hulls from time to time with completely satisfactory results.

In amplification Mr. RYMILL'S observations on optimum resin/glass ratios for mat laminates, the Authors would like to refer to Mr. J. A. Raymond's paper given at the Reinforced Plastics Congress, which puts the case for higher ratios much more fully. Stiffness is often a primary consideration, hence Fig. D 1 of this paper is particularly relevant.

TYLERS welcome confirmation that the distance between stiffeners, i.e. the clear panel area, is normally used in the Society's calculations. It is agreed that the effect of additional reinforcement varies with it's extent, but the Authors prefer to consider the shell as a continuous skin rather than an isolated panel with simply supported edges.

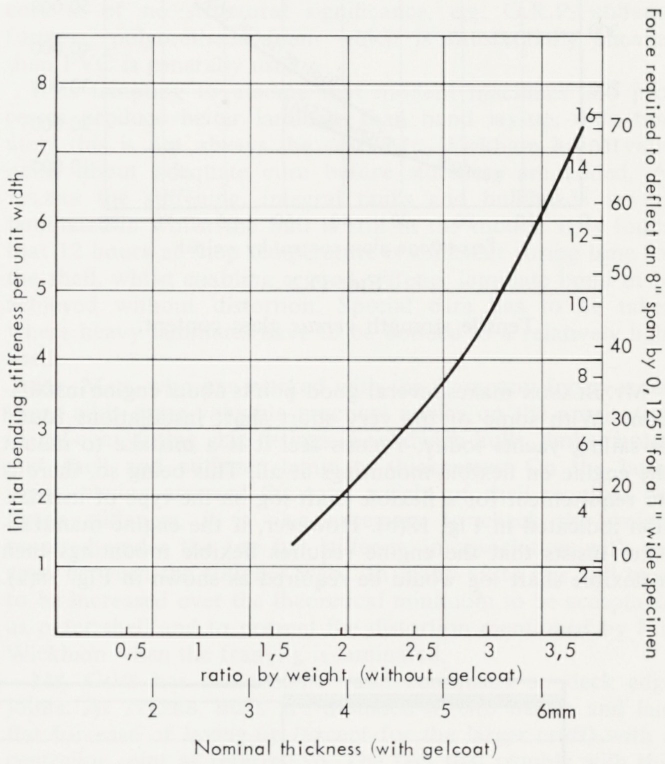

FIG. D 1

Laminate bending stiffeners *versus* thickness.

The Authors are unable to understand how using unidirectional rovings in place of bi-directional rovings, of equal weight, warp and weft, can have such a small effect on the tensile modulus as Mr. Rymill suggests. Commonsense would indicate that if the number of fibres in the direction of load is doubled, the tensile load carrying capacity will be doubled. The Authors are indebted to Pilkington Brothers Limited for Fig. D 2 and suggest that this is an area which could bear further investigation.

Semi-circular G.R.P. tube limbers look good on a drawing, but in practice on larger craft they are overlaid by so much frame and girder laminate that they end up deeply embedded in the hull.

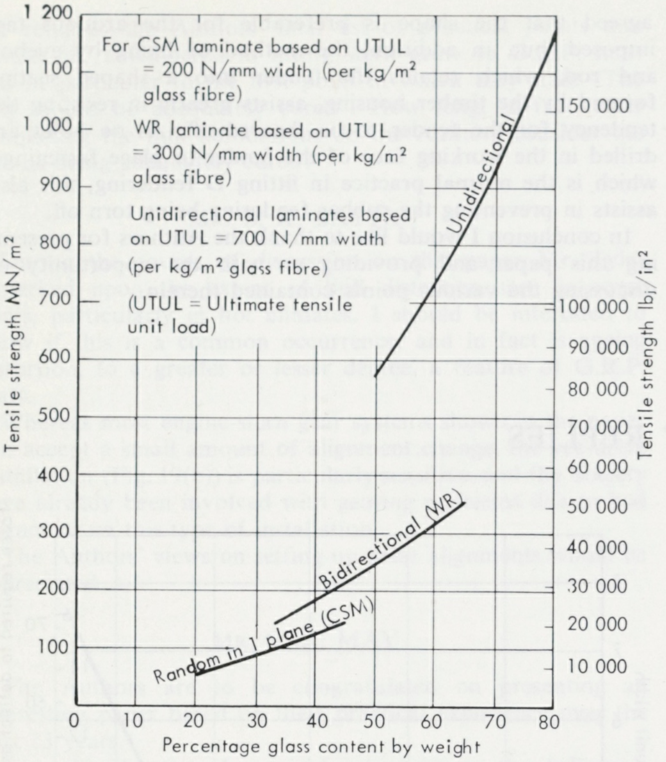

FIG. D 2

Tensile strength *versus* glass content.

MR. BEASON makes several good points about engine installations. With some of the very short shaft installations found in sailing yachts today, TYLERS feel it is a mistake to mount the engine on flexible mountings at all. This being so, there is no requirement for a flexible shaft log on the type of installation indicated in Fig. 18(b). However, if the engine manufacturer insists that the engine requires flexible mountings then a flexible shaft log would be required as shown in Fig. 18(a).

An example of a G.R.P. stern tube is shown in Fig. D 3(a). This is laid up over a solid mandrel and not over a thin bronze former. It is fitted with water lubricated bearings at both ends. The inboard end of the tube is moulded to form a substantial flange with nuts moulded in for the gland bush securing studs. The outboard end is securely bonded to the hull and the inboard end bolted to a G.R.P. web. A lantern ring separates the gland stuffing from the water lubricated bearing. Mr. Beason does not like greased inboard bearings in conjunction with water-cooled outboard bearings as shown in Fig. 20. If both bearings are solid and greased the outboard one is even more prone to wear, if both are water-cooled there is more chance of the inboard bearing overheating due to insufficient cooling with a moderate sized engine and a water-cooled exhaust.

In the example shown in Fig. 21(a) the stern tube is bonded to the hull at the outboard end and bolted to a G.R.P. web at the inboard end, as shown in Fig. D 3(b) opposite. In Fig. 21(b) the installation shown has the inboard flange similarly bolted to a G.R.P. web, whilst the outboard flange is secured by bolts tapped into the skeg laminate.

Unquestionably it is good practice to continue engine bearers as far aft as the stern tube and 'P' bracket and this is standard practice on power boats. TYLERS have not found this necessary on smaller yachts because the hull shape makes this a very stiff area, already reinforced with the keel or joining mats. As far as fitting stern gear is concerned TYLERS consider a hull to be adequately cured after six days at shop temperature.

With reference to Mr. FRYER's remarks about supporting rudders, we are considering relatively small yachts here and must get away from 'what is normal on all ships' and get down to the simplest and most economical methods. We do have alternative filling materials, one of the most successful being pulverised fuel ash mixed with resin at 1 : 1 by volume. This provides an economical filler where foam is undesirable. of Lloyd's supervision although the Company system of

As regards quality control, customers may have the option inspection is important. There are also certain things with which the Society's Surveyors may not be directly concerned,

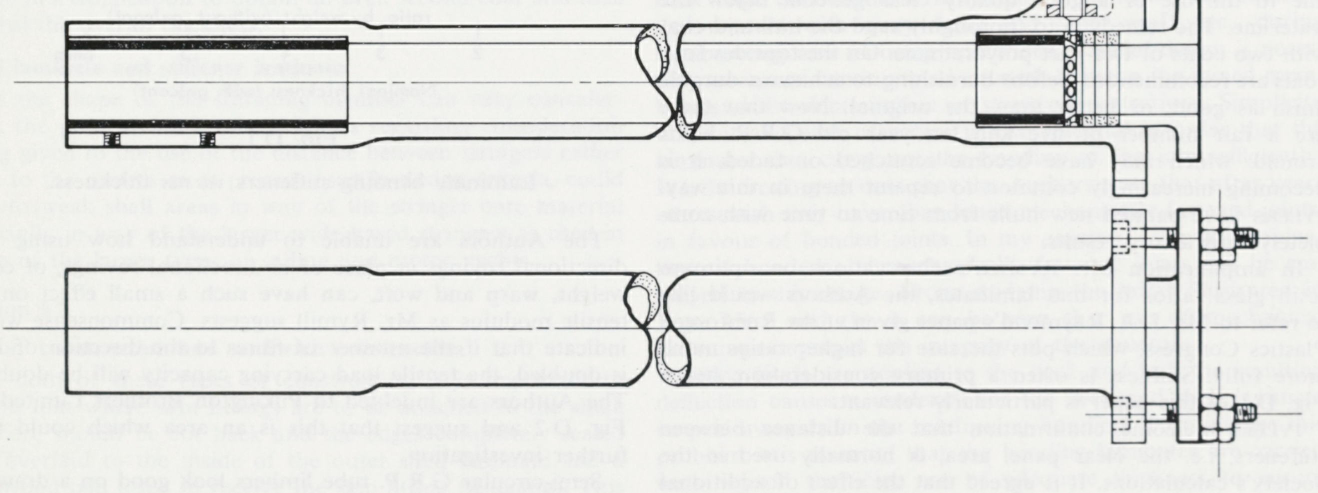

FIG. D 3(a)

G.R.P. stern tube.

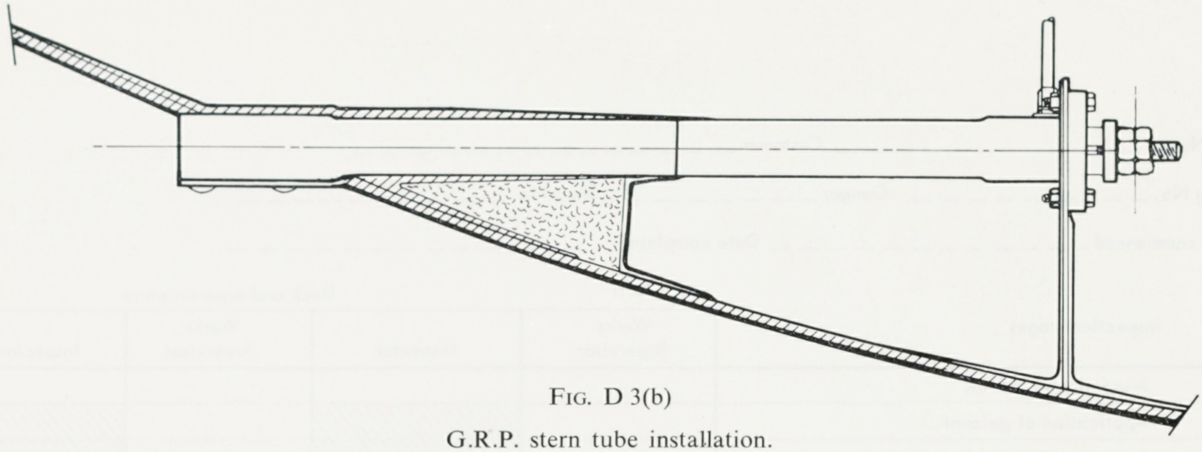

FIG. D 3(b)

G.R.P. stern tube installation.

but which matter to the Company and to its customers. Such inspection not only saves the Company expensive rectification, but enables faults to be eliminated at source. Briefly the system of quality control is as follows,

1. A quality control inspection sheet, Fig. D 4, is issued for each boat.
2. The Works supervisors are responsible for all stages of manufacture and must accept or reject the mouldings at each of the stages indicated.
3. At certain important stages (1, 9(a), 10 and 14) the Company's inspector also checks the mouldings.
4. After laminating is complete, a full inspection (stage 17) is made before the mouldings are moved to the ancillary shop.
5. When the required ancillary items, such as the rudder, engine and sterngear, stemhead, chain plates and windows have been fitted, these are checked by the Company inspector (stage 19).
6. Finally, after loading, a last inspection is made to ensure that damage has not occurred at this stage.

In addition, quality control department has a patrol inspection unit whose responsibility it is to ensure that the correct methods laid down are strictly adhered to. Having the Company inspector present whenever the factory is working is a major contribution to maintaining the quality of TYLER boats. When a Surveyor finds anything detrimental, he brings it to the attention of the Company's inspector, who resolves it with the Works Manager to the Surveyor's satisfaction.

Mr. Fryer is right about the difficulty of assessing hull thickness, but TYLERS mark each mat, or woven roving, with a distinctive colour stamp, so it is possible to count the layers in the laminate. These layer markings are particularly obvious in the unpigmented bottom shell.

Mr. WICKHAM asks about the economies of sandwich construction. It must not be forgotten that for a practical sandwich hull the outer skin must be thick enough to withstand local impact and puncturing. The overall weight of a 'Tyton' linked sandwich hull is similar to a conventional single skin and stiffener laminate and costs a bit more due to the higher cost of the core material and the extra labour. On the subject of core materials for plain sandwich construction, especially above the waterline, the higher properties and bond strength of end-grain balsa make it the preferred material. Where the core is of no structural significance, e.g. G.R.P. stiffener formers, polyurethane foam which is substantially cheaper than PVC is generally used.

It is tempting to assume that modern machines and processes produce better laminate than hand lay-up, unfortunately this is not always the case. Mr. Wickham has a valid point about adequate cure before stiffeners are added. At TYLERS the stiffening, integral tanks and bulkheads are all laminated-in whilst the hull is still in the mould. It is found that 12 hours at shop temperature is sufficient curing time for the shell, whilst enabling a good stiffener laminate bond to be achieved without distortion. Special care has to be taken where heavy laminates have to be bonded to a relatively light shell.

Mr. MAY, who has worked with the Company for over ten years adds some valuable practical advice on the application of gel-coat, fitting skin fittings in sandwich hulls, limber holes, and shell and stiffener laminate thicknesses. On the latter point, having assessed the total weight of shell required between stiffeners, it is also necessary to check the weight required under the top hat stiffener, in association with the span between the stiffener webs. In many cases this will have to be increased over the theoretical minimum to be acceptable as outer shell and to prevent the distortion mentioned by Mr. Wickham when the framing is laminated.

Mr. CANE has made some valid comments on deck edge joints. At TYLERS, hulls are moulded in two halves and laid flat for ease of laying-up (except for the larger craft) with a centreline joint as referred to. The fact that trouble with this bonded joint is virtually unheard of strengthens the case for properly bonded joints. In this case the layers are invariably staggered back from the joint and it may well be that a development of this technique could be used with advantage on the equally vulnerable deck edge joint.

Through-bolted toe rails are often fitted to TYLER yachts and cover the joint illustrated in Fig. 15(a) resisting the tendency to peel. It is important from the moulders point of view to have a strong and watertight joint when the mouldings are delivered.

On the subject of high duty fendering there is another approach. BP have developed a plastic with a low dynamic coefficient of friction, which enables the boat to slip along, or up and down more easily. This may reduce damage caused by the tearing action mentioned by Mr. Cane when the fender takes a grip.

Job No. ________________ Customer ____________________

Gang No. __________ Ganger __________ Shop No. __________

Date commenced ________________ Date completed

Inspection stages	Hull: Works Supervisor	Hull: Inspector	Deck and superstructure: Works Supervisor	Deck and superstructure: Inspector
1. Inspection of moulds				
2. Application of gelcoat				
3. 1st Layer of mat.				
4. Main laminate and hull joining				
5. Stiffeners and local reinforcement				
6. Scuppers				
7. Chainplate anchorages				
8. Ballast and covering laminate				
9. a) Tank layout				
b) Tank laminate				
10. Mast step/cofferdams				
11. a) Layout of bulkheads				
b) Bulkhead bonding				
12. Linings and insertion				
13. Cutting down bulkheads				
14. Bonding deck to hull				
15. Initial inspection after releasing				
16. REPAIRED AREA (after 15)				
17. Complete check of laminating				
18. Ancillaries				
19. Final inspection				
20. After loading				
21.				
22.				
23.				
24.				
25.				

Random checks on

Thickness: Hull topsides __________ Middle __________ Bottom __________

Deck __________

Weight of mouldings ________________

FIG. D 4

Quality control inspection sheet.

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LLOYD'S REGISTER AND THE MARINE ENGINE BUILDER

A. Schiff
(Guest Speaker)

Paper No. 5. Session 1974-75

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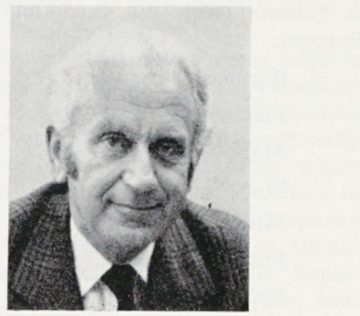
LLOYD'S REGISTER AND THE MARINE ENGINE BUILDER

Read before the Technical Association by Dipl. Ing. A. Schiff, C.Eng., M.I.Mar.E., Member of the Board of Management Maschinenfabrik Augsburg - Nurnberg Aktiengesellschaft, the President, Mr. F. H. Atkinson in the Chair.



MR. A. SCHIFF

TABLE OF CONTENTS

1. Classification of a Large Diesel Engine.
2. Machinery Plan Approval.
3. Protoype Diesel Engines.
4. Method of Survey and Survey of Sub-Contracted Parts.
5. Surveyors' Inflexibility
6. Guidance, Assistance and Communications.
7. Classification Societies—Help or Hindrance
8. Amalgamation of Classification Societies.
9. Spare Gear.
10. Machinery Installation.
11. Impartiality.
12. Conclusions.

1. Classification of a Large Diesel Engine

When Adolph Schiff, a shipowner of Elsfleth, Germany, and Messrs. Robert Thompson & Sons of Southwick, Sunderland, signed a contract on 18th August, 1890, to build a ship 'to be known in the Builder's books as No. 168', the text of the contract contained the words *"Class: To be classed in Lloyd's Registry 100A1, and built under the special survey of their Surveyors, and in accordance with the approved amidship section."* There was no further reference to other parts of the ship. A similar position prevails today. The major part of classification regulations concerns the construction of steel ships. Experience and work on such vessels dates back to the second half of the 18th century. Diesel engines and steam turbines, however, were not invented until the end of the 19th century and have been playing a major role as marine propulsion units only for the past 75 years.

The classification procedure is clearly defined for ships of steel construction. It is expressly laid down in the Rules which documents and drawings are to be submitted and which calculations are to be carried out. This also applies to systems design and arrangement in the machinery sector, i.e. there are clear-cut rules for the size of bilge and ballast pumps, for the fire extinguishing system, the safety systems, the electrical installations, etc. For the diesel engine itself there are specifications as to the size of the starting air vessels, the size of the safety valves on the engine housing and cylinder covers, for the crankshaft dimensions and for the torsional vibration calculations to be carried out. The scope of on-board spare parts is also laid down. The diesel engine builder must provide details of the engine characteristics in the event of turbocharger or unit failure, etc. However, the Surveyor must also work from the documents provided by the engine builder, i.e. he is given data on the test run (of the prototype) which is to be reproduced after installation on board the ship during sea trials.

The engine builder himself provides a guarantee directly to the shipyard and indirectly to the shipowner with regard to rating, speed, fuel consumption, derating for changes in ambient or seawater temperatures before the charge-air cooler. In addition, recommendations are frequently made with regard to time between overhauls of individual components, cooling water additives, lubricating oil quality and consumption, etc. The engine as such, however, is designed without consulting a classification society; the service characteristics and readings taken are demonstrated on a prototype and it is the duty of the classification society to deal with this data in a more or less intensive manner. In contrast with ship design practices, it is the manufacturer who possesses the experience necessary for the design of new diesel engines, not the classification society. The research results obtained by the diesel engine manufacturer are not given to the classification societies in detail, so that the Society has no opportunity to deal with design details apart from standard calculations of strength, stress, thermal deformation, etc.

The number of manufacturers of large two-stroke diesel engines can be quickly counted. They are, in alphabetical order:

Burmeister & Wain	Denmark
Doxford	England
Fiat	Italy
M.A.N.	Germany
Mitsubishi	Japan
Sulzer	Switzerland

The manufacturers of large four-stroke diesel engines, which are usually medium-speed types, are, basically speaking, as follows (with the exception of the USA and Eastern Europe):

Burmeister & Wain	Denmark
Fiat	Italy
MaK	Germany
M.A.N.	Germany
Mirrlees	England
Mitsui	Japan
Pielstick	France
Stork-Werkspoor	Holland
Sulzer (part design with M.A.N.)	Switzerland

This indicates that there is a limited number of manufacturers of diesel engines, and the closeness of the circle is itself conducive to a fruitful co-operation with the classification societies. These statements cannot be applied to manufacturers of small diesel engines even if they do produce large quantities.

2. Machinery Plan Approval

For large diesel engines a varying number of drawings are required to be submitted to the classification societies. The nature of these drawings further indicates the difference between ship and engine plan approval procedures inasmuch as the data supplied is primarily for the information of the classification societies. However, all classification societies lay down rigid dimensioning formulæ for the crankshaft. It is an undisputed fact that these formulæ basically (and when progressed) give proper attention to all factors affecting durability, such as engine service data, geometry, materials, etc. Considering that these formulæ came into being a long time ago and are predominantly based on empirical values, it is all the more noteworthy that no cases are known in which crankshafts designed essentially to these formulæ have failed. A detailed examination, however, will show that certainly not all influences on durability have been correctly quantified in all formulæ. As an example, for the crankshaft of one of our engines, the dimensioning formulæ of various classification societies differ in such a way that they produce quite a wide range of permissible firing pressures with fixed geometry and cylinder output. This fluctuation can range between 106 and 175 bar. Whereas the higher value is hardly applicable today, the lower value represents a limitation which forces us to make occasional changes which cannot always be technically justified. The fact that technical improvements clearly representing an increase in crankshaft durability are not always duly recognized in classification society formulæ is another impediment to the designer of a highly-rated engine.

This state of affairs has the result that M.A.N. does not in the first instance design crankshafts to the formulæ of the societies, but according to the general principles of the science of engineering materials. A reference stress is calculated according to the Mises criterion which comprises the maximum bending and torsional stresses at the most heavily stressed point. As a possible failure of the crankshaft might be caused by the maximum reference stress, maintenance of special limit lines for the torsional vibration load becomes superfluous in this procedure. The reference stress calculated is matched with the fatigue strength of the material and a safety coefficient is thus obtained. The maximum bending and torsional stresses to be included in the reference stress are calculated with the aid of stress concentration factors from nominal stresses. These stress concentration factors are taken from an investigation carried out by the German Internal Combustion Engines Research Association (FVV), which has obtained extremely reliable curves with the aid of a large number of test models. As far as the calculation of bending stresses is concerned M.A.N. have ascertained by means of thorough theoretical investigations (the results of which have been compared with measured values) that the statically determined calculation method applied to loads caused by firing and inertia forces produces an upper limit which gives, as opposed to the actual condition, a 'hidden safety margin'. The nominal torsional stress is worked out on the basis of forced attenuated torsional vibrations in the entire engine plant. Measurements have shown that the actual readings obtained coincide with the values calculated within a tolerance of ± 10 per cent. By examining a number of borderline torsional vibration cases in one engine series it can be ensured that the maximum torsional stress, which occurs later, is applied.

The major difficulty in determining the safety coefficient lies in establishing the strength of the material to be used. The fatigue strength, which alone is decisive, depends to an unreliable extent upon static strength values, surface quality, component size and the production process. When using fatigue strength values, M.A.N. bases its conclusions on a fairly large number of test results, which can be obtained from a great variety of points on full-size crankshafts; it is felt that the maximum reliability possible today has been achieved in this respect.

It will be recognized that great effort is being devoted at M.A.N. to the correct technical design of such a major component as the crankshaft. It would be a good thing if discussions could be held on this subject with the aim of securing an easy-to-grasp and technically correct calculation procedure for future classification purposes.

3. Prototype Diesel Engines

Genuinely new designs are relatively rare for two-stroke engines. It is usual for predominantly tried-and-tested designs to be taken as the basis for further development. One exception to this was the development of two-stroke diesel engines with bores of 850 to 1006 mm back in the 1960's. This pioneering work has now passed into technical history. The sole exception nowadays is the engine with a 940 mm bore, 2500 mm stroke and a cylinder output of 4230 kW (5500 bhp) at 83 rpm publicized by Burmeister & Wain a year ago. This data corresponds to a mean effective pressure of 17·5 bar, whereas all two-stroke engines of this size presently on the market scarcely exceed the 12 bar limit.

At the moment several companies are developing four-stroke engines with a bore of 600 mm and above, which all produce an output per cylinder of 1490 kW (2000 hp) at speeds between 375 and 428 rpm. In this respect inroads have been made into real virgin territory and the performance results of these new designs under demanding service conditions at sea is awaited with keen interest. If dimensions are increased then problems which are not inherently applicable with smaller dimensions might arise. The manufacturers' knowledge is growing quickly, but no one is immune to phenomena which were hitherto unknown. Every manufacturer will therefore carry out his preliminary trials in an extremely careful and

job-oriented manner. The question is therefore whether the danger of setbacks can be reduced by calling in experienced classification societies in good time. There are some classification societies which have a wealth of experience for specific problems and which can be consulted on the basis of previous publications.

Records and card index files, registering experience obtained with and damage sustained by ships, which the various classification societies maintain, are important in the context of consultation and M.A.N. would very much welcome a move to facilitate access to the card index file or records system of Lloyd's Register. It goes without saying that the Society would provide data only on the engines of the actual manufacturer concerned. But the provision of such data would also afford the Society's specialists an opportunity to get together with the designers and test engineers and discuss the cause of damage which has occurred and hence determine the exact reasons for this. The classification societies could thereby exert a certain amount of influence on future engine design over the years to come. Nor are there at present any clear-cut rules applying to all classification societies, i.e. specifications issued by IACS for prototype acceptance. The conditions which must be met for series registration of a new type of engine should be very clearly defined: a major point being that acceptance of a prototype should take place on the premises of the licensor only and that demonstrations of this type should not have to be repeated later on by all licensees.

4. **Method of Survey and Survey of Sub-contracted Parts**

It is the duty of the Surveyor to see, in an impartial manner and using his technical expertise and experience, that major components comply with the Rules. Here the Surveyor acts on behalf of owners, underwriters and, last but not least, on behalf of people who will later wish to sail aboard the vessel in safety. Nowadays a high standard has been reached. Classification societies cannot be judged by whether the standard is too high or too low, but quite simply by whether they are in a position to delegate surveyors with the necessary understanding of the subject and the requisite analytical ability.

As the specific horsepower of diesel engines increases, the demands made on the material properties grow constantly, thus for components subjected to great stresses it becomes more and more necessary to carry out non-destructive tests, e.g. in the case of steel castings. The definition of permissible faults should also be included under this heading. There is no generally acceptable defects list for large diesel engines. The points most frequently discussed being the surface quality of cylinder liners, and the admissible defects for highly-stressed steel castings and components of complicated design, e.g. piston crowns and crank throws. The degree of differentiation in the manner in which defects in steel castings, for example, are to be assessed is particularly apparent in the crank throws of two-stroke engines. An M.A.N. proposal (Fig. 1) provides for a crank which is divided into zones of stress. M.A.N. intends to permit technically justifiable defects of magnitude graduated according to service load. On the one hand this enables the mechanical properties of the steel castings to be better exploited and consideration to be given to the most economical method of producing them, and on the other it provides a certain aid to assessment at all levels of inspection. Comparative assessment sheets already exist, for example, for piston crowns and cylinder cover bottoms of alloyed steel castings (Fig. 1). These also indicate areas where faults may be ground-off and welding undertaken. The examples shown indicate that only the most highly stressed zones are likely to give problems whereas in other surface zones a certain level of defects may be quite permissible.

Supervision of sub-contractors' items is in some aspects inadequate. Improved vigilance on the part of the classification societies is particularly recommended during the casting of any materials. Engine manufacturers are continually sustaining considerable losses in machining castings which have been accepted but finally reveal unacceptable defects in the finished state. There is frequently a wide discrepancy between the qualities of materials used for cast or forged test bars and those used for the actual components. Supervision of casting or forging techniques and subsequent heat treatment must be intensified. It should be agreed with the diesel engine manufacturers where the test bars are to be cast and not left to the foundries.

5. **Surveyors' Inflexibility**

This question does, in fact, affect not only the Surveyor, but also the Society's Headquarters and the manufacturers themselves. Surveyors know that in the case of a complaint they cannot simply demand from the manufacturer that the workpiece be re-submitted in perfect condition at a later date, but must give indications or even assistance as to whether and how this improved condition can be reached. For this the Surveyor requires more documentation on permissible defects. If he has lucid documents on this and has been working with them for some time, co-operation between Surveyor and manufacturer can be improved further. It remains to be discussed whether a Surveyor should be transferred more frequently by rotation. The Author is of the opinion that it is sufficient for the Surveyor to be sent by Headquarters to courses at regular intervals and for the manufacturers to be asked to invite the Surveyors to attend technical symposia. The latter would promote an understanding of overall technical interrelations on the part of the Surveyors. Attendance by Surveyors at the technical proceedings of licensees' conferences would be a step in the right direction.

6. **Guidance, Assistance and Communications**

The assistance of Lloyd's Register in dealing with difficulties can only be acknowledged with gratitude. Manufacturers are given prompt and well thought-out technical guidance, so far as this is within the ability of the Society. But it is always a question of the personalities involved as to whether or not this assistance leads to success. This is an opportune moment to thank the gentlemen of the Society who, with their vast wealth of experience, have rendered assistance in difficult cases. However, there are some urgent cases where an on-the-spot decision is necessary. Here great demands are frequently made on those Surveyors present at the manufacturers' premises. The Surveyor should nevertheless be able to approve the despatch or repair of components without referring to Headquarters if the shipowner is in agreement with this. In many cases, particularly in repairs, an arrangement of this kind would greatly alleviate problems. The path taken by a query directed to Headquarters may at times be tenuous and time-consuming. There is not always sufficient time for this, although it is usually quite adequate for normal approval procedures.

Shipbuilding is very much a matter of confidence. If a shipowner orders a vessel, this shows that, in the past, he has

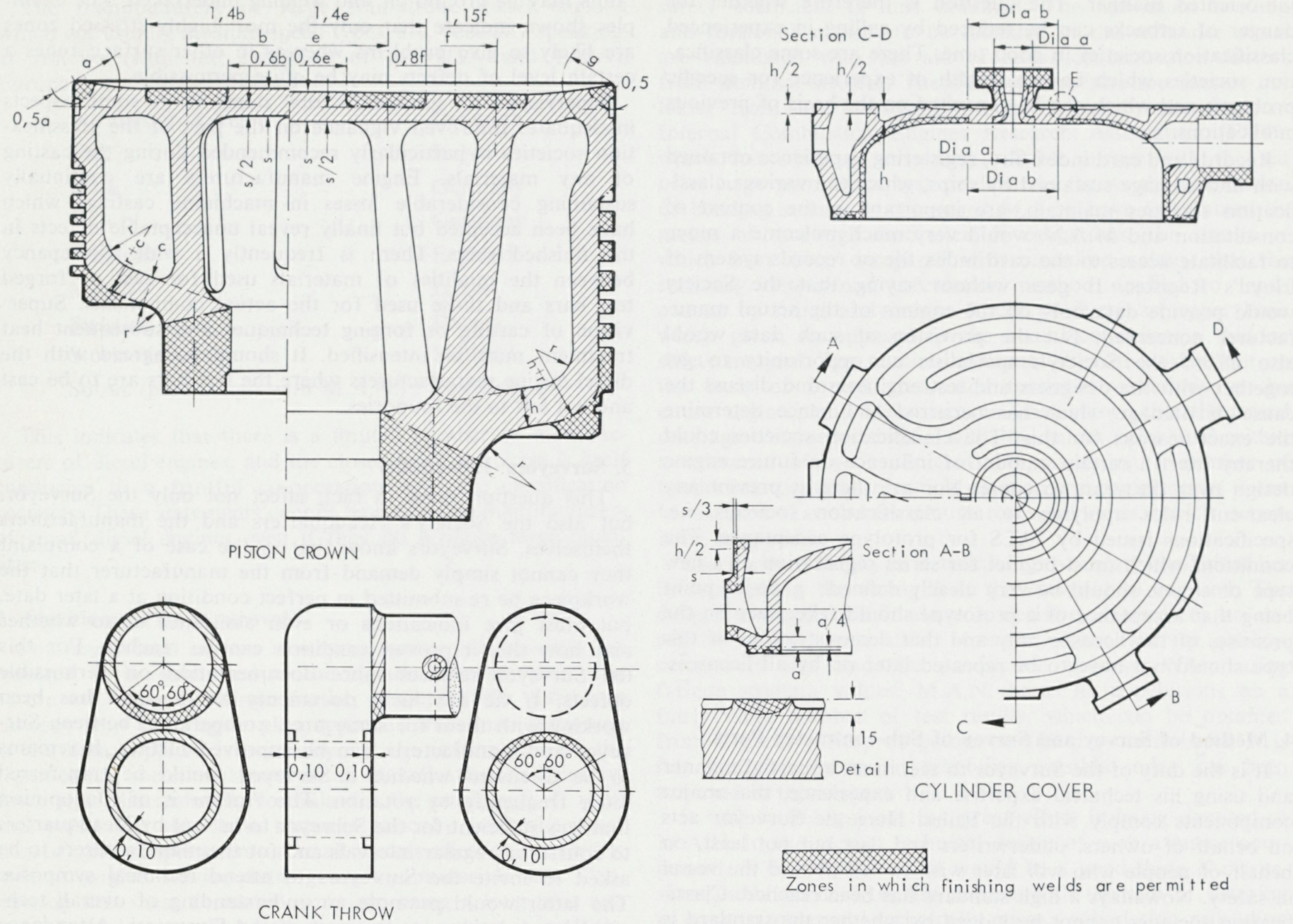


FIG. 1

Areas of admissible defects.

always had the necessary confidence in the shipyard and the sub-contractors specified, including the diesel engine manufacturer. Today building contracts change hands even before the keel of the ship has been laid. Anonymity is encountered time and time again. The old form of co-operation and confidence between Mr. X of the shipyard and Mr. Y of the shipowners is being replaced by a high degree of formalism. This is not necessarily an instance of progress. It would nevertheless be a good thing if the designers at the engineering works had more personal contact with the specialists at Headquarters in dealing with matters concerning the former. Headquarters must often rely on queries conveyed by telephone and the reliability of information given in this way can only be accepted with confidence if the person at the other end of the line is personally known.

7. **Classification Societies—Help or Hindrance**

The activities of the classification societies are helpful from the point of view of the engine builder in the sense that they ensure a worldwide standard of quality for the sub-contractor and engine manufacturer, their worldwide practical experience having a beneficial effect everywhere in rendering assistance in technical development. The acceptance certificate provides the customer with documentary evidence that the technical side of the contract has been fulfilled.

From this definition it is clear that the Society is a help to manufacturers. The methods of ensuring quality must be further refined, but safeguarding of quality is best left in the hands of the classification societies. The diesel engine builders would be quite incapable of inspecting raw materials and parts purchased from sub-contractors.

8. **Amalgamation of Classification Societies**

The amalgamation of classification societies is a subject with both technical and political implications. The technical side must be based on the fact that there is only one 'technical truth'. To this, economic considerations must be added, since amalgamation would lead to unrestricted standardization of specifications, standards would become uniform and the production activities of manufacturers processing raw materials would become cheaper.

From the political point of view, however, an amalgamation of this kind is quite impracticable. Attention should be given to the eastern European countries, which will certainly not be willing to merge with western classification societies. Not even the amalgamation of the remaining classification societies is feasible. Every developing country building its first shipyard simultaneously founds its own classification society. This is

part and parcel of the sense of national pride in these countries, and such tendencies are deeply ingrained. There might be a solution on a smaller scale, a question of whether or not amalgamation of the classification societies in the EEC could be achieved. Bureau Veritas, Det Norske Veritas (Denmark, but not Norway and Sweden), Germanischer Lloyd, Lloyd's Register and Registro Italiano class a very large percentage of world tonnage. This union could be the crystallization point for the addition of further classification societies. But if a look is taken at the EEC, then it would appear that such a step could be realized only very slowly. Should a country leave the EEC one day, attempts at an amalgamation of this type would collapse immediately.

The most practicable solution at present is IACS. Here the most important rules are being harmonized, and this work is deserving of full support. But a second difficulty now arises. The national authority in the United Kingdom is the Department of Trade and Industry. This is represented at foreign shipyards by Lloyd's Register. The German Seeberufsgenossenschaft is represented by Germanischer Loyd. If an amalgamation of the EEC classification societies were to take place, it would be necessary for safety regulations in the various countries to be harmonized such that the common classification society could additionally act on behalf of the various national authorities.

In Germany, the Seeberufsgenossenschaft is composed of an equal number of representatives from the employers' federation and from the trade unions. It is difficult to judge whether this would promote or hinder standardization of specifications.

Much as an amalgamation would be welcomed from the manufacturers' point of view, the road to realizing this will not be a 'bed of roses'.

9. Spare Gear

The scope of spare gear is uniformly defined by all major classification societies in the western world. This has led to the fact that even spare gear which the manufacturers consider useful has been deleted from the list. It can be roughly estimated that sufficient spare gear is placed on board for two-stroke propulsion systems. In the case of four-stroke engines and multi-engine systems powered by four-stroke engines the scope of spare gear is too limited. This should not, as previously, cover individual major components only, but be specified for the first 5000 hours' service on heavy fuel. All leading shipowners order an additional supply of spare gear at the same time as ordering the ship; although this puts up the contract price, it is still considered necessary. If the manufacturer of the main marine propulsion system has also signed a maintenance contract, he will immediately put more spare gear on board the ship than the classification societies call for.

10. Machinery Installation

Although crankweb deflectiton is checked when a Diesel engine is installed on board a ship, the drawings of the steel construction of the ship are not checked to see if the double-bottom construction is sufficiently rigid and that the crankshaft is sufficiently protected from bending and twisting in the hull. There is to date no formula for determining the maximum permissible deflection of the engine bedplate and hence the crankshaft. It should, however, be possible to determine limiting values in co-operation with the engine manufacturers.

The present arrangement, whereby a theoretical shaft bending line is calculated for high-power systems and is then translated into practice when the ship is fitted out at the yard, refers to the zone between the propeller and the output flange of the engine. The engine itself is virtually excluded from these calculations. Even the material to be used and the geometry of the chocks are given different specifications by the various shipyards. The same applies to grouting compounds, which plastics producers have recently been promoting more and more. It is in this very field that 'experimental' ships should be put into service with the assistance of the classification societies and the consent of the shipowner, so that universally valid experience can be gained and the findings subsequently published. The manufacturers of diesel engines are quite willing to render assistance in establishing documentation of this type and supplying statistical material.

11. Impartiality

Being impartial makes great demands on the Surveyor. Nevertheless, the Author knows of no noteworthy case in practice in which this impartiality has been breached. This is in praise and recognition of the activities of the Surveyors.

A difficult question in this context is whether the classification society should be named in the arbitration clauses of purchase contracts as the final court of authority for technical matters. In cases where material defects leading to damage are not discovered until after the vessel has been put into service the classification society becomes involved, e.g. if materials test certificates based on misrepresentations on the part of sub-contractors have been issued. State institutions for testing materials are frequently brought into cases of this type and some underwriters have set up their own laboratories capable of carrying out materials tests according to the latest state of the art. Such investigations are also connected with a certain partiality if the underwriters are involved in the insurance risk.

M.A.N. has no misgivings when it comes to calling in Lloyd's Register to settle technical disputes as an impartial arbitrator.

12. Conclusions

The Author has attempted in this paper to point out the major aspects of the inter-relationship between a large diesel engine manufacturer and Lloyd's Register. Here it should be recognized that there is much common basic work to be done in the future of quality control. Beneficial co-operation is also urgently needed in the field of reliability engineering. The quality characteristics of engineering materials, e.g. low cycle fatigue, will in future play a more and more important role, and the application of experience gained by the classification societies should be of major assistance. Co-operation is imperative for detecting the causes of damage, and joint conclusions should be drawn from these findings. Shipbuilding is a challenge, and so is marine engine building. The famous names in shipbuilding today will play only the smallest role in this age of rapid advance. Today, the progress achieved by this technology is subject to permanent evolution; but progress is also made up of teamwork in industry itself, between shipyards and sub-contractors, between all concerned with the construction of a vessel, including the classification societies with their experience feedback and their surveyors on duty throughout the world. Ships have been in service for millennia and have shaped the destiny of many nations and families for just as long. Co-operation to make these ships still safer and better is therefore a challenge to all of us.

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Lloyd's Register Technical Association

Discussion

on

Mr. A. Schiff's Paper

LLOYD'S REGISTER AND THE MARINE ENGINE BUILDER

Paper No. 5. Session 1974-75

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Discussion on Mr. A. Schiff's Paper

LLOYD'S REGISTER AND THE MARINE ENGINE BUILDER

Mr. B. HILDREW

The paper presented by Mr. Schiff is a stimulating one and I would only wish to comment on a limited number of points which relate specifically to the service this Society tries to provide to ship and engine builders.

Our card index file of machinery failures which we had maintained for over 20 years had become particularly unwieldy and thus a decision to transfer the file on to the computer has enabled us to reassess the information which may be desirable to record and store. In addition, it is now possible to ensure that common types of failure, occurring over a long time spectrum are automatically programmed to identify a commonalty and to alert technical staff to the problem. This service is available to manufacturers, although naturally it is necessary to charge a fee to cover the cost of extracting specific information from the data bank.

Whilst accepting the desirability of prototype acceptance by the major classification societies, to extend the acceptance to all licensees is difficult. Licensors vary in the strictness of control they impose on the licensee and in emergent countries it is not unusual for design detail and material specification to vary to meet the indigenous capability in the particular country.

On another issue, where repairs are required to major components under manufacture, Headquarters main function is to provide additional technical advice and support, if this is necessary. However, Headquarters recognises that the field Surveyor, who is dealing directly with the hardware, is in the best position to make a technical judgment. It is, however, reasonable to carry the prospective owner along in agreement and some owners are often influenced by non-technical issues.

The function of a classification society can vary depending on the adequacy of the quality assurance within a firm. Unfortunately, very frequently the classification society surveyor is the only quality control imposed on the manufacturer and, in such circumstances, he is forced to spend the greater portion of his working time in direct attendance on the shop floor. In fact a surveyor should provide an independent quality control of the firm's quality control and should when visiting a firm become an integral part of that firm's quality assurance team. It is significant to us in L.R. that the more successful firms in the world are those who are quality conscious and willingly invite an external involvement with their own agreed quality procedures.

Mr. Schiff's comments regarding classification societies within the E.E.C. are particularly noted, as L.R. has, of course, given this matter considerable thought. Unfortunately, our experience in Europe to date has indicated a greater drive towards maintaining and extending a national identity rather than a Community identity and this is particularly apparent at present in the Community's proposed directives relating to pressure vessels where the concept of a totally independent technical assessment to be made by an organization freely chosen by the purchaser will no longer be permitted.

The Author's statement regarding spare gear is noted. The major classification societies, after long discussion collectively and in association with C.I.M.A.C., arrived at a unified requirement for spare gear and L.R. is loath to deviate from this agreement.

The use of plastic chocks under auxiliary engines is now common practice and there are also a number of main engines which are similarly supported. The Society has carried out a considerable amount of research into the creep properties of these materials at temperatures which are commonly found at bedplate/engine seating. Very few of the synthetics presented to us have been able to meet the very limited creep tolerance required and care must be exercised in accepting the suitability of location when using such materials.

In conclusion, may I say how greatly I enjoyed reading the paper and how very much I agree with the cogent arguments summarised in it.

Mr. S. N. CLAYTON

On a personal note may I first say that it was a pleasure to be associated with Mr. Schiff during my period of service in Germany. He is a sincere friend of the Society and, as a good friend should be, is not averse to calling a spade by its rightful name when he feels there is cause and he anticipates the same frankness in return.

In an exchange of views last year between M.A.N. and the Society, a sketch was supplied by M.A.N. showing more detailed zones of stress in a crankthrow than are indicated in Fig. 1 of the subject paper. I suggest that the former sketch could with advantage be reproduced when the Discussion to this paper is printed.

Mr. Schiff has referred to permissible defects in these zones but not to weld repairs. On the other hand Chapter R(H) of the Rules stipulates areas where welding of a cast steel crankthrow can be tolerated but does not list permissible defects. A further exchange of views between the engine builder and the Society on this question would be beneficial.

While sympathising fully with Mr. Schiff over the problems of defects found during final machining it must be borne in mind that in examining castings in the as-cast or rough machined condition the Surveyor will not be in a position to find the less visible defects without recourse to grinding and the use of non-destructive testing methods.

This is an area where, as emphasised by Mr. Schiff, co-operation between the engine builder, foundry and classification society is essential because extra charges are levelled by the foundry for non-destructive testing work and not all orderers are disposed to accept the additional cost at this stage. As an example of co-operation I would cite the case of main-bearing stools manufactured in the Ruhr area some years ago where certain defects only came to light after the castings had been incorporated into the bedplates. A specification was drawn up between M.A.N. and the foundry with the Society also being involved which helped to obviate the problem.

More recently in this continuing field of co-operation, the Society's Surveyors have been fully involved in M.A.N.'s proposals for the fabrication of pistons for the KSZ 105/180 type engine. Indeed, the results of the prototype tests are now under consideration in this Office.

On a final note may I say how fitting it is that Mr. Schiff should have accepted the invitation to present this paper. I say this because his company can with pride point out that they were the builders of the first prototype engine designed

by Rudolf Diesel in 1893. This engine stands in the M.A.N. works museum in Augsburg.

Mr. C. DEARDEN

Anyone who starts out with the laudable idea that crankshafts are very simple bits of mechanism and that there ought to be a rigorous method of evaluating their load capacity will be able to pick holes in the analytical background described in any technical paper on the subject and it is safe to say that no matter to what degree of academic refinement this subject may in future be pushed, the opportunities for 'hole-picking' will not be sensibly diminished.

An easy way of making an outward show of the 'divine dissatisfaction' that has attracted so much admiration in the past is to complain that not enough research is being done on this or that and to lament the fact that we don't know the first thing about the fundamentals of say intergranular forces in the material of the crankshaft. The obvious comment on the first complaint is that it is not true and on the second that for practical purposes it is not necessary. What has certainly been lacking in the past is the type of research that gives a simple answer to each of the questions a designer must ask himself. It is noticed that in this respect the builders of large marine diesel engines including the Author's Company have not only asked these questions, but have had the advanced technical means to answer them. Engineering is an art born of commercial necessity.

The description of the M.A.N. design and manufacturing procedure is noted with interest and details would be appreciated for information purposes. It is stated that the reference stress is considered in relation to the fatigue strength and a safety coefficient is obtained, could the Author state the nature of this safety factor? A copy of the report of the investigations carried out by the German I.C. Engine Research Association (F.V.V.) on the subject of stress concentration factors would be very helpful for reference purposes. Despite the design procedures outlined in the paper, it seems we are still dependent on a hidden margin, perhaps more truthfully a factor of discretion, since in engine design this appears to be inevitably so. What areas of investigation would the Author recommend in endeavouring to pierce the darkness covered by the 'hidden margins'?

The Society very properly takes note of all the engineering knowledge that becomes available and certainly collates the extensive information fed into Headquarters by the Surveyors in the Outports.

With regard to the use of classification formulæ for the design of crankshafts, I well remember receiving the design portfolio of one engine builder; this contained extensive instructions on all aspects of the engine design, entablature bearing loads, oil film thicknesses, etc., and tucked away in one small section 'scantlings of crankshaft to Lloyd's Rules'. We would not, however, conduct research with such relentless rigour and with complete disregard of the extent by which its results may disconcert users of existing information in the same field nor formulate arithmetical procedures that would be too laboured to apply to commercial designs. With regard to the range of permissible firing pressures referred to in Section 2 of the Author's paper, some years ago, when the geometry of the vee-engine was being explored by designers and considered in conjunction with the increase in power to be expected from turbo-charging we were not infrequently requested to supply an interim formula, since at that time we had no published rules for vee-engines. This usually took the form of a simple graph connecting maximum pressure plus a constant multiplied by mean indicated pressure and it was surprising the number of times people ignored the thermodynamic fact that the maximum pressure and mean indicated pressure are rigorously connected. It comes, therefore, as a surprise to notice in Section 2 that it was the lower maximum pressure of 106 bars that affected the durability of the crankshaft particularly as there have been suggestions in the press that a beneficial decrease of the maximum pressure of combustion could possibly be obtained even with turbocharging if blast-injection were re-introduced.

With regard to the submission of engine plans for general approval the practice has been not only examination for compliance with the Rules, but very often an appraisal in depth taking account of the bending and twisting moments the maximum and minimum values of these moments being used to obtain the mean and half range values, these are then combined with the nominal section moduli, stress concentration factors, endurance limits, and yield stress to obtain safety factors in accordance with the Soderberg formula. I would venture to say at one time or another every aspect of the complex structure of engine and entablature has been looked at by the Society including flexibility of crankshaft elasticity of engine frame, not forgetting the effect of oil films, bearing pressures, vibration phenomena, materials, processes and dynamic effects. So the problem in developing formulæ applicable to crankshafts must be to take into account the above varied factors in a way that avoids conflict with average experience. We accept the conventional principles of stress, elasticity and vibration. We take into account relevant research results so far as we can and we attempt a reconciliation with general service experience. Our procedure is that tacitly followed by all engineers. Where a problem is simple we solve it, where it is difficult we approximate and solve a simpler form of it, where it is insoluble we guess intelligently, but at all times we keep an eye on what we have done before and although we do not welcome breakdowns they do assure us that we are not consistently working on a basis so eminently safe as to be unnecessarily costly.

Mr. Schiff, thank you for your paper, it has stimulated me into fresh thought on so ancient a subject, for I understand that it was under the Sung Emperors that this uncommonly simple but yet profound device was first conceived, but it has had an uncommonly long gestation period in the West. Thank you.

Mr. R. R. HOLTUM

I should first like to join my colleagues in thanking the Author for coming here tonight to present his paper. The paper quite naturally concentrates on the design and construction of new engines but as the Author rightly points out, there are few really new designs, the majority being developments of existing types with modifications based on their behaviour in service.

In this context reference is made in the paper to information gathered by our Surveyors and the suggestion is made that we should make available to engine builders defect and damage data covering the service behaviour of their particular engines. I must point out that this information, in the form of statistical analyses, is always available on request but we would prefer builders to specify which areas or components they would like us to investigate.

We have on occasions drawn the attention of engine builders (not M.A.N. I hasten to add) to a particular problem and have then been told that they were already fully aware of the trouble. So that whilst I agree with the Author that the Society's data should be available to the builder I do feel that the understanding should be mutual, with the builders telling us of any problems they find in service rather than leaving us, in all cases, to find these out for ourselves.

Clearly, there are areas where one side will have better information than the other. For example, builders should be very well informed regarding such items as cylinder heads and liners since they supply the spares and in many cases will know the reason for replacement, whether because of wear and tear or defect. On the other hand classification Surveyors are usually called in for defects such as cracking in bedplates or entablatures and in these instances the builders will not necessarily be informed.

I think I should add here that our Technical Records Department have long since abandoned the simple card index files to which the Author refers. We have operated for some time a sophisticated data retrieval system based on the Society's IBM 370 computer which can be programmed to provide statistical print-outs and, in the case of major components, figures relating to reliability and the probability of failure. Our data base, containing records of ships built since 1960 is used extensively both within Lloyd's Register itself and by the shipping industry generally.

With regard to failures in service I wonder if the Author could tell us a little about the technical relationship between the engine builder and his licensees. We are sometimes confronted with engine damages apparently resulting from a detail design fault such as an engine-driven pump drive, and it is difficult to establish whether the particular detail is a feature of all engines of the type or only those built by an individual licensee. In some cases we have received circulars issued by licensees to owners of ships engined by them offering guidance and instructions which may well be at variance with recommendations made by the licensor.

In his conclusions the Author speaks of the need for cooperation in the field of reliability engineering and I would support him entirely. Indeed, one of the principal aims of both the engine builder and Lloyd's Register is that of increased reliability. We both have a great deal to gain from such a joint enterprise and I am sure that by combining the data at our disposal we could achieve worthwhile results in establishing causes of defects and damages.

Mr. J. Milton

In Section 10 on machinery installation the Author begins by stating that crankweb deflections are checked when a diesel engine is installed on board ship and goes on to state that the drawings of the double bottom construction are not checked to see if there is sufficient rigidity in same to prevent subsequent distortion of the crankshaft under operating conditions at sea.

This is an aspect in which I have always been interested and during my spell in charge of the Society's Engineering Investigation Department some years ago we did in fact measure the deflections of a Doxford bedplate in a seaway. The maximum deflections recorded were about 0·025 in upwards and 0·011 in downwards. As these deflections are in excess of the main bearing clearances it follows that the crankshaft must be influenced, and this dynamic influence would be additive to any malalignment existing through conditions of loading.

With regard to crankshaft deflection readings, present day crankshafts are so stiff that the true value of these readings as a guide to alignment can only be relied upon when it has been proved that the crankshaft is down in its lower half bearings—and in this respect, it has often been suggested, particularly in the case of medium speed engines lifted into a vessel in one piece, that reference pads be embodied on each side of the bedplate, outside of the engine, and that these pads be machined on their top faces at the same setting as for boring of the main bearing pockets. Checking of alignment would then, at any time, be a simple and accurate operation. The Author's views on this would be appreciated.

As a safeguard against crankshaft troubles it would appear that the essentials are: firstly, a rigid engine—not one of lightweight 'strong' fabricated design which can be bent by hull deformations, and, secondly, a hull which although for lightness incorporates special steels, is still rigid enough not to deform in way of the engine seatings. If these criteria cannot be satisfied there would appear to be no alternative but to flexibly mount the engine in the hull, and this would entail other undesirables.

Mr. R. F. Munro

Some builders of large marine diesel engines put enormous effort into development work by long-term test bed running while others appear to achieve the desired result by in-service testing of individual newly-designed components with the aid of friendly shipowners.

Would Mr. Schiff care to say how his company deals with this matter?

I can see one difficulty in connection with the last paragraph in Section 4 concerning the plea for improved vigilance on the part of the classification societies when dealing with castings. It is agreed that the position of the test bars is a matter to be settled between the designers and the steel foundry and it is known that manufacturers strongly influence casting techniques by issuing detailed specifications, but these are matters over which the Surveyors have no control, while they may well be involved in the testing of castings which have not been so produced (sometimes known as 'pirate' castings).

In Section 5 the suggestion is made that engine builders should invite Surveyors to attend licensee's conferences. This was is fact adopted some years ago at Winterthur and proved of great interest as well as promoting a much clearer understanding of the day-to-day problems of the manufacturer.

In conclusion may I ask Mr. Schiff to tell us why M.A.N. number their cylinders from aft when nearly everyone else counts from forward? This, on occasion, gives *us* some problems!

Mr. P. Manson

I have found Mr. Schiff's paper on the relationship between Lloyd's Register and the Marine Engine Builder, of great interest. In this connection I would appreciate his comments regarding the following points which are raised in the order as listed in the table of contents.

In Section 1 Mr Schiff states that in contrast with ship design practices, it is the manufacturer who possesses the experience necessary for the design of new diesel engines, not the classification society. Like ships, however, new engines are based on

existing designs and here I feel the Society has a wealth of knowledge of the problems associated with the running and maintenance of marine diesel engines, which I consider would be of great benefit to a diesel engine manufacturer, who is perhaps considering producing a new engine or modified design of an existing engine. For example, a few of us can remember the special arrangements for the supply of high pressure lubricating oil to the crossheads of the early Sulzer 900 mm bore engines built in 1929, which, of course, were subsequently discarded in later designs and are still omitted to the present day. I am sure Mr. Schiff has been asked on many occasions whether the crosshead booster pumps, as still being fitted on the slow speed M.A.N. engine, are in fact, necessary. I know quite a few marine engineers have raised this question, without obtaining a satisfactory answer. This is an example in which the Society's knowledge, if sought, would be very valuable to the designer, and could well result in a saving in engine manufacturing costs.

Having in the past been closely associated with marine engine builders in Japan, where as most of us know, the Sulzer, M.A.N. and B & W Engines are built under licence, it was my experience to be involved in discussions on problems that arose from time to time. I found that any departure from design, or modifications, for example as in the case of the adoption of the thin shell bearings on the crossheads of the Sulzer engines was, in the first instance, tried out on ships built for domestic owners with their agreement. Subsequent testing proving successful, it was my understanding the information was submitted to the licensor for final approval, as a standard for all engines fitted on domestic or export ships. It is well known that the thin shell crosshead bearings are standard today for the slow speed Sulzer engines.

I am rather interested in Mr. Schiff's remarks in Section 2 to the effect that no crankshaft designed on formulæ laid down by a classification society have failed. This is not my experience, and I am sure our Records Department will be able to clarify this point. However, I would agree that the reliability factor has improved considerably over the past decade or so, particularly in the case of the so-called slow speed diesels. It is my personal opinion that of a number of factors which account for this the basic ones are the new processes in some parts of the world in the manufacture of castings and forgings, and in particular, quality control procedures. Unfortunately, there are areas in the world where this is not so, and until this situation is changed any review of the formulæ that may be anticipated would, in my opinion, have to reflect this factor. I would respectfully refer Mr. Schiff to a paper given at the Institute of Marine Engineers in London in 1968 on the fatigue strength of large cast steel crank throws for marine diesels by Dr. Nishihara and co-authors.

In Section 3 Mr. Schiff makes a major point that acceptance of prototype engines should take place on the premises of the licensor only and that demonstrations of this type should not have to be repeated later on by all licensees. It has been my experience that the prototype of all the Sulzer RD & RND engines, including some of the earlier designs, were first produced in Japan. This also applies to B & W engines and I am reasonably sure that the first KSZ 105×180 M.A.N. engine was built in Japan in 1971. I conclude that in such cases the licensor would not wish to carry out any further tests or demonstrations on his own premises.

On the subject of admissible defects as discussed in Section 4, I refer to Fig. 1 crank web and pin where the areas of admissible defects and zones in which finishing welds should be permitted are shown. In all my experience I have not encountered a combined crank web and pin casting where consideration has even had to be given to doing such a repair in the areas indicated in Fig. 1. In works where I have been concerned, if defects were found that required cutting out and welding in the area indicated, the casting would be rejected by the Works Quality Control Department, without even consulting classification. It may be that a printer's error has occurred in the areas shown where weld repairs should be permissible.

I fully endorse the remarks on sub-contractors, in fact, I would go so far as to say that quality control is in some cases sadly lacking, and I agree that sub-contractors of all people require a degree of vigilance not normally required in some of the larger organizations. I must say, however, that there are a few sub-contractors who do have a good quality control system in operation.

Flexibility, as discussed in Section 5, is a problem which I feel will come more to the fore in the future and, in fact, to some degree is with us today. However, in my opinion, experience is the best teacher and provided an engineer is keen and observant there are plenty of opportunities from time to time which enable him to broaden his experience. In Lloyd's Register we have always been in a position where, should a particularly difficult problem arise and the Surveyor concerned is in doubt as to his recommendations for repairs or acceptance of an item under dispute, he need only call for advice from his Principal or Senior Principal at the port and in most cases this advice is readily given. There should not be, therefore, any appreciable delay in settling a particular problem. It is very rare that a situation arises where a particularly difficult problem has to be referred to London. In such a situation we generally find that it is not only the Society's Surveyor, but the owner's representative also, who has to refer to his Head Office for a decision, and I would suggest that this happens more often in the case of an owner's representative than in the Surveyor's case.

Differring views prevail regarding the period of training which a Surveyor should have on joining the Society. A lot depends on the background of the new entrant. In some quarters the minimum period for training is considered to be two to three years, during which time the young Surveyor should have an opportunity to gain experience of steel works' procedure, especially for forgings and castings. This is a field in which very few engineers during their early careers ever have an opportunity of gaining any experience. A good insight into new construction and repair industries of course is very necessary, in fact, this is something that a Surveyor in any major Outport is very much involved with during his career as a field Surveyor. The above, coupled with courses at the Society's training facilities at Crawley, should give the Surveyor a good base from which to start.

As opposed to the Surveyors attending licensee's conferences, would it not be possible for reports of the conference to be forwarded to the Society's Headquarters for examination and study? By this means, Headquarters could reprint the relevant technical data pertaining to alterations in design for subsequent circulation to our Outport offices, thus reaching a broader field of our technical staff than would otherwise be the case. This procedure would be particularly useful for our overseas Surveyors who may come across a problem relating to, say, a modified design of a particular engine.

On the subject of spare gear it has always been a vexed problem as to how much a ship really requires to carry. I doubt whether one would get two superintendent engineers to

agree on what is considered adequate. I would suggest that classification requirements cover the essentials to enable the ship's engineers to keep the machinery in good running order at least until the ship reaches port. I am sure there are many engineers who have been on board ships where some of the spare gear is so coated with paint that one has difficulty in identifying its purpose, and of course many ships go to the scrap merchants carrying spares that have never been used in the life of the ship.

The diesel engine maker in my opinion should also study the question of demands for spare parts. Mr. Schiff has indicated that in the case of four-stroke engines and multi-engine systems, the scope of spare gear is too limited. Is it not possible for members of the Diesel Engine Manufacturers' Association to get together and draw up a list of what is considered essential. As a result of studies based on demand through their respective departments handling the supply of spare parts. Having done this, their recommendations could be submitted for consideration by the Society.

I fully agree with the remarks in Section 6 on experimental ships. There would appear to be more scope for this arrangement in the Far East than there is in Europe. Whether shipbuilders and others arrange very attractive terms to shipowners as against their European counterpart I don't know, but from my experience there appears to be a greater scope for testing new ideas in the Far East than there is here.

In conclusion, I would like to thank Mr. Schiff for a most interesting paper.

Mr. R. M. LEACH

Like the preceding speakers, I would like to thank Mr. Schiff for coming here tonight to present his paper which has been written in a forthright and concise manner. Many of the more technical points have already been under discussion in some detail and I would like to make a few remarks concerning a less technical although none the less important subject of spare gear.

Broadly speaking I think the Society's philosophy and indeed, so far as I am aware, the philosophy of all classification societies on this subject is that only such components, the failure of which would disable a ship and which are able to be fitted by ship's staff at sea, need be carried as Rule spares. It is, of course, recognised that it is difficult to incorporate this policy in any Rules which are intended to be applied to all types of marine installations without producing a separate and very large volume of the Rules.

The current spare gear requirements so far as main engines are concerned were introduced into the Society's Rules in 1972 after their general adoption by the member societies of IACS. In this connection, the items of spare gear required for oil engines were only decided upon as a direct result of consultations and agreement between an IACS working party on engines and C.I.M.A.C. (*Conseil International des Machines a Combustion*—an association of leading engine builders).

It would, therefore, appear that the Engine Builder plays no small part in deciding what spare gear should be carried as a classification rule requirement and at this stage the engine builder is given the opportunity to put forward his points of view on this matter.

Since 1966, in order to comply with SAFCON requirements, items of spare gear required for Class should be subject to checking by the classification surveyor at periodical surveys. Should it be found that spare gear is in any way deficient it is the duty of the Surveyor to recommend that the deficiency be made good at an early date. It is the policy in this Society to make the replacement of such spares a condition of Class. In any case at any time when spare gear is utilised it is the responsibility of the owner to make good the resulting deficiency at the earliest opportunity and this is a Rule requirement.

It follows that, even the most careful owner will not take kindly to a classification society that requires large amounts of spare gear to be carried which, though not essential for the safe operation of the ship, might be very necessary for the efficient operation of the machinery as any prudent owner would demand.

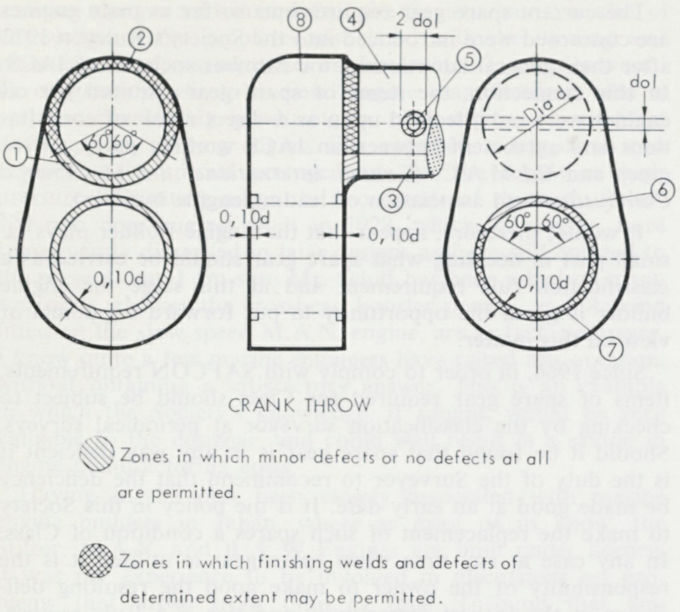
As Mr. Schiff so rightly remarks, all leading shipowners place on board spare gear additional to that required by the Rules and such action can only be applauded. It is surely the owner's right, however, to remove or replace non-essential spares as he may desire in consideration of the conditions or trade in which the ship is operating so as to avoid having large amounts of non-productive capital tied up in spare gear.

It is expected that all owners are sufficiently responsible to supply additional gaskets, jointings bolts and other materials in their own interests and similarly it is concluded by the classification societies that any special tools, lifting gear, etc., will be available on board for the fitting of any essential parts. It is further concluded that all necessary manuals and instructions for repairs and adjustments will be supplied by engine builders.

AUTHOR'S REPLIES

Apart from the requirement emphasized by MR. HILDREW on the use of cast resin chocks that alignment of the engine must not be disturbed by creep phenomena under static loads, it is important to answer the question of whether the transverse dynamic forces can be absorbed without slipping or wear. As a variety of condtions may prevail with regard to internal mass forces and forces of deformation induced by deformation of the hull, we consider it worthwhile to completely explore, by means of selected tests, those limits within which cast resin chocks may still be used in terms of these criteria.

As surmised by MR MANSON, a printer's error has occurred in the sketch of the crankthrow in Fig. 1. MR. CLAYTON rightly recollects that eight zones were distinguished in the original M.A.N. proposal, in which various magnitudes of defect may be permitted as a function of the stress level. The legend in the sketch showing zones in which weld repairs are permitted may only be applied to the cylinder cover. The complete sketch of the crankthrow with eight zones mentioned above is shown in Fig. D 1. The magnitudes of defects ascertained for engines of our KSZ series will be noted from the accompanying table.



Zone	1	2	3	4	5	6	7	8
defect size (mm)	0,0	1,5	3,5	5,0	1,9	1,0	1,5	7,0

FIG. D.1 Zones of admissible defects.

It will be realized that the cross-shaded areas in the sketch of the crankthrow originally printed are the very ones in which the smallest defects or no defects at all are permitted (*see Erratum*). In this respect, M.A.N. are always interested in holding an exchange of views on the admissibility of weld repairs in cast engine components.

Mr. Clayton's objection concerning the untraceability of minor defects in castings in the as-cast or rough-machined condition is quite correct: this cannot, regrettably, be contradicted, as in many cases even small defects cannot be accepted and testing calls for grinding the surface. In this context it is merely a financial question of who is to bear the costs. In the paper, the 'less visible defects' were intended in terms of admissibility. Sufficiently large and readily visible defects must be detected and removed at the manufacturer's works at all costs.

Supervision of applied technologies primarily refers to lapses in quality often connected with modifications to tried and tested processes made to streamline production.

I should particularly like to thank MR. DEARDEN for his contribution, as he has taken the trouble to comment in great detail on that part of my paper in which I referred to a certain discrepancy between the crankshaft design specifications of the various classification societies and the calculation procedures applied in practice by most major engine manufacturers.

I do, of course, agree with Mr. Dearden that one can pick holes in any published calculation method for the crankshaft. However, I cannot accept the conclusion that the research results available for correct design of this component are really sufficient nor that they are unintelligible to the average designer. Thus, although it is possible in most cases today to calculate in advance torsional stresses in a crankshaft to an accuracy of ± 10 per cent, this does not apply to bending stresses, because too few metrological and computational findings are available on the rigidity of crankshafts and engine frames. If further practical and theoretical work is being done in this field (in which case it is mainly a great deal of results scattered over the greatest variety of points which would have to be collected), I think that the prospects for calculating in advance the total actual stresses in a crankshaft in the not too distant future with similar accuracy will not be as poor as those for torsional stresses today. The fatigue strength values required for quoting with similar accuracy a numerical value for technical reliability, which are at least as reliable as we are accustomed to using for other applications, are lacking. I feel I have made it clear that there is still a lot of useful work to be done in this field.

We are, of course, willing to discuss the calculation method I described and applied by M.A.N. with your experts at any time.

The most valuable examination carried out by the FVV, which I mentioned, on stress concentration factors has been published in abridged form in the journal *MTZ, 1973*. Issues 7 and 9, to which the Society will certainly have access. If Mr. Dearden is interested in looking at the actual final report of the FVV, which has been published as their *Research Report No. 130*, I can gladly provide a copy by kind permission of the FVV.

I am not of quite the same opinion as Mr. Dearden with regard to the equivalence of the term 'hidden margins' with the concept 'factor of discretion'. By hidden margin I meant that margin arising when not all factors can be determined with the greatest possible accuracy, when a calculation procedure which can still be controlled in practice is applied and when a conscious effort must then be made to err on the side of caution. I am very well aware that in many cases the classification societies apply calculation methods, especially for crankshafts, which are in line with the latest state of the art. What we regret is the fact that the discrepancy between such calculation methods and the calculation formulæ laid down in the guidelines of the classification societies today is too great. We apprecate the efforts made by the classification societies not to impose too complicated calculation methods on the engine manufacturers. Yet if it is considered that the calculation formulæ contained in today's guidelines came into being a long time ago, it is understandable that, in view of the enormous progress made by computer technology in the meantime, the calculation methods applied by the manufacturers have overtaken the level of these simple formulæ.

Mr. Dearden appears to have misunderstood my remark that a permissible firing pressure range of between 106 and 175 bar has resulted from applying the crankshaft design formulæ of the various classification societies to one and the same example. I did not mean that difficulties with the durability of the crankshaft would have occurred even at the lower limit value. I intended rather to show that the theoretical calculation of the permissible firing pressure possible today for a particular crankshaft can scarcely be scattered over such a broad range. The permissible firing pressure calculated according to our method is, in fact, in the lower part of the scatter range quoted, but still notably above the lowest value. However, in order to meet the requirements of the classification societies without making recourse to the rather questionable practice of obtaining 'special permissions', we would have to take technical measures to set the firing pressure at a figure lower than that we consider correct.

Cases of the type depicted by MR. HOLTUM in the penultimate paragraph of his contribution were quite conceivable in the earlier relationship between licensor and licensee. Today and in the future all licensors will, to an increasing extent, pay more attention in a more rigorous form to see that all parts subjected to great stresses or wear are absolutely identical, regardless of whether they are manufactured by licensor or licensee.

MR. MILTON makes a good suggestion in his third paragraph which, as far as we know, has already been adopted by several manufacturers. M.A.N. would in future like to tread a somewhat different path. At present we are looking for a simple and trouble-free method of pressing the crankshaft down onto the bottom bearing half shell and of measuring crankweb deflection at the same time. This method also makes allowance for the fact that crankshafts—particularly those in medium-speed engines—are to an increasing extent becoming so rigid that it cannot be safely assumed that the crankshaft will seat properly in its bearings with the conventional method of measuring crankweb deflection used today. As these shafts almost invariably have counterweights on all webs, the play can scarcely be measured with the feeler gauge. The method we are aiming at has extra advantages when it comes to replacing individual bearing shells.

With reference to the second and fourth paragraphs of Mr. Milton's contribution, unfortunately very few definite figures are available on hull and bedplate deformation. We have reconciled ourselves to the fact that we cannot build engines that are so rigid they do not undergo any deformation along their length due to bending of the hull. But we are on the way to working out permissible limiting values for this deformation. It must be borne in mind that the crankshaft must withstand this bending; allowance must be made when the crankshaft is designed for the additional bending stresses occurring. However, attention must also be paid to the stresses and relative movements in and between the structural components of the engine and to the loads applied to the bearings. In smaller medium-speed engines, including marine propulsion units, separation of ship and engine is, in fact, a feasible procedure: if the engine frame is rigid enough to absorb all forces generated within it, flexible mounting is an elegant solution. Mutual influences of engine and ship are obviated; great comfort is afforded by dispensing with insulation against structure-borne noise and the saving on expensive chocking work can make flexible mounting interesting in terms of price.

In reply to MR. MUNRO's remarks on Section 3 of the paper every engine manufacturer does, of course, make an effort to carry out all essential trials on his own testbed. There is no doubt that, especially in the case of higher-output engines, this procedure does not always afford adequate scope for continuous operation and hence long-term testing. Although computer technology and modern metrological techniques render this superfluous in many cases, corroboration of testbed, metrological and computational results by findings from continuous in-service operation—whether it be in a power station or aboard a ship—is always a welcome addition. Such in-service testing can, of course, only be done with intensive supervision by the manufacturer and special arrangements with the shipowner. May I also point out that the numbering of cylinders from aft complies with an ISO standard adopted quite some time ago. A renewed application to have this changed was again rejected by the responsible body only last year.

The statement in Section 2 of the paper doubted by MR. MANSON, i.e. that no crankshaft designed to formulæ laid down by a classification society has failed, has been changed in sense by a slight inaccuracy in the translation. The German text stated that no crankshaft thus designed has failed *essentially*. Various cases of damage not caused by faulty design but explainable in terms of faults in materials used or irregularities in operation should be excluded from this statement. What was meant was that no crankshaft thus designed has undergone serious damage. It is taken for granted by us that with the higher and higher stresses applied to the crankshaft more exact methods of calculation are only worthwhile if advances in production and testing procedures keep up with them. A licensor is also responsible for seeing that his licensees can maintain the same standard in terms of these procedures. Even steel castings with defects which, according to statistics, take a certain pattern still have a tangible durability. In an investigation for the example of certain crankthrows carried out by L.R. in co-operation with the manufacturer and ourselves we were able to prove this only a short time ago. However, as our experience shows that the quality situation with cast steel has progressively deteriorated on a world-wide scale, a transition will have to be made to an increasing extent of manufacturing crankthrows from forged material instead of casting them, if difficulties are to be obviated from the outset.

It is certainly correct, as Mr. Manson suggests, that many cylinder arrangements of an engine already developed or newly developed engines are nowadays also demonstrated for the very first time at licensees, particularly in the case of larger-bore engines. This often depends on which member of the entire licence family has built the first model of a new engine type. In this case renewed type testing at the works of the licensor himself should certainly not be necessary. It should also be said, by way of correction, that the first engine of type KSZ 105/180 was not built in Japan, but at the parent works of M.A.N. in Augsburg.

On the subject of licensee's conferences M.A.N. believe that a good deal of the questions discussed concern highly specialized single questions. It would hardly be correct to distribute on a wide scale the complete minutes of such a conference dealing with a host of questions on mutual relations between licensees and licensor. We feel that the suggestion made in the paper that Surveyors not only be trained further by their own societies but also be invited to technical symposia held by the manufacturers to which they are assigned would better reach the aims set, not least of all because it promotes the personal relationship between Surveyor and manufacturer.

On the subject of spare gear Mr. Manson makes a very good suggestion. It is conceivable that the classification society will receive proposals from all major manufacturers and incorporate parts such as fuel delivery pipes or complete exhaust valves, to which universal standards apply, in its own rules.

ERRATUM

In Fig. 1 of the paper areas of admissible defects on a piston crown, cylinder cover and crankthrow were denoted by cross-shading. For the crankthrow and the piston crown, the areas of cross-shading and single shading were mistakenly reversed. For the correct areas and sizes of admissible defects for the crankthrow refer to Fig. D. 1 of this Discussion. Note: the areas of admissible defects on the cylinder cover remain in order as shown in Fig. 1 of the paper.

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LLOYD'S REGISTER TECHNICAL ASSOCIATION 1920—1975

FIFTY-FIVE YEARS IN RETROSPECT AND PROSPECT

The presentation of this index provides the opportunity to offer some information regarding Lloyd's Register Technical Association to those who may find it of interest and who, perhaps, may not be fully aware of its concept and function. The purpose of the Association, as stated in its constitution is "The advancement and dissemination of knowledge in Shipbuilding, Marine Engineering and other matters of technical interest, by the preparation and discussion of communications on the various aspects of the subject".

The inaugural meeting was held on the 6th October, 1920, at the London Headquarters office. For the first fifty years it was known as Lloyd's Register Staff Association, but was renamed in 1970 to avoid confusion with a new organisation formed to perform a function within the Society in association with Management concerning staff interests.

The purpose of the Technical Association is achieved by the presentation and discussion of papers written by Surveyors, other members of staff and invited authors, in various ports throughout the world. The Technical Association plays no part in any official business of Lloyd's Register of Shipping and its operation and direction from Headquarters are matters of convenience for administrative reasons. Throughout its fifty-five years it has been well served by a number of honorary committees and examination of the contents of this index is considered to reveal this as amply self evident. Two hundred and eighty papers have been presented during the period 1920–1975. It can be fairly claimed that for technical merit and variety of subjects, together with depth of scientific and practical knowledge reflecting experience throughout the world, the Technical Association Transactions can stand proudly in comparison with the annals of any of the learned societies or professional institutions.

The high calibre of papers over the years reflects with accuracy a remark made by the first President of the Association, Mr. W. Watt at the inaugural meeting at which he said "The formation of the Association commences another chapter in the long and honourable history of Lloyd's Register and I venture to think that in it we will write a chapter which will hold its own with any that have gone before".

How true his remarks have proved to be can be seen by an examination of the contents of this index. Mr. Watt went on to comment about the need for specialisation within the Society and his observations have become increasingly accurate with the passing of years. This again can be seen to be reflected in the title and content of several of the papers which have been of great help to Surveyors in the course of their duties all over the world. In this way the Association has provided and continues to offer a valuable service in addition to the interest to be found in the papers.

To some extent the transactions reflect various technological developments in Shipbuilding and Marine Engineering during the past fifty-five years and in this connection it may be considered that they are gradually acquiring some historical value. They also provide a means of bringing the names of some of their respected predecessors to the attention of succeeding generations of Surveyors who come and go on the tides of time. The transactions provide a means of storing some of the experience and traditions of the past and disseminating knowledge of present practice, thus fulfilling the prophecy that the Association "will write a chapter which will holds its own". Examination of papers of recent years indicates that this, as always, continues to be the case and may be regarded as a re-assuring sign for the future. From the scope and variety of subjects covered it can be observed that the Association has maintained its particular position in the field of technical literature.

The present era is one of steady technological advance and development, with the emphasis on the intensity and increasing diversity of engineering, shipbuilding, marine and non-marine structural design and construction. These factors influence the Society's work and in turn provide challenge and opportunity to the affairs of the Technical Association. Experience over more than half a century shows that potentional Authors are to be found within the Society to meet these challenges. It is clear that there is as much opportunity and need now, for papers on a variety of subjects both general and specialist, as there has even been during the period covered by this index. Therefore it is hoped that, in addition to providing what may be found to be a useful reference, the index will provide some stimulation and guide to subjects which may be usefully dealt with in the future. Many papers, found helpful in the past and relevant to subjects of the present day, could be brought up to date with much advantage to the present Surveying Staff. The need for papers, dealing with the specialist subjects which the Society's work increasingly requires in a number of fields, may be considered to be clear. It was said in 1920 that the field was large and the subjects numberless. What was true in 1920 must be even more applicable after fifty-five years.

These notes also provide the opportunity of expressing grateful appreciation for the generosity and support of the General Committee of Lloyd's Register without which the Technical Association could not have functioned for fifty-five years and reached this particular stage in its progress. Appreciation must also be expressed for the splendid assistance given by the Printing House Staff who over the years have played their part, often under pressure of work and sometimes in adverse circumstances, to ensure that the papers are printed.

In conclusion it is desired to express grateful thanks to Mrs. R. J. Hook whose assistance has facilitated and expedited preparation of the classified arrangement of this index.

PAST PRESIDENTS

	Session
WATT, W.	1920–21 and 1923–24
CARNAGHAN, J.	1924–25
LAWS, B. C.	1925–26 and 1926–27
CHALMERS, A. A. A.	1927–28
HECK, W. D.	1928–29 and 1929–30
THOMSON, W.	1930–31 and 1931–32
DOREY, S. F.	1932–33 and 1933–34
BLOCKSIDGE, E. W.	1934–35 and 1935–36
RITCHIE, G. D.	1936–37 and 1937–38
WARD, R. J. L.	1938–39
ASSOCIATION SUSPENDED FROM SESSION	1939–40 and 1945–46
SHEPHEARD, R. B.	1946–47 and 1947–48
WATSON, G. O.	1948–49 and 1949–50
COCKS, F. C.	1950–51 and 1951–52
MOFFITT, R.	1952–53
MURRAY, J. M.	1953–54 and 1954–55
McAFEE, J.	1955–56 and 1956–57
TURNBULL, J.	1957–58 and 1958–59
SIGGERS, H. B.	1959–60 and 1960–61
BUCHANAN, G.	1961–62 and 1962–63
ARCHER, S.	1963–64 and 1964–65
JENSEN, C. J. G.	1965–66 and 1966–67
GRAY, D.	1967–68 and 1968–69
STOOT, W. F.	1969–70 and 1970–71
HINSON, A. R.	1971–72 and 1972–73
ATKINSON, F. H.	1973–74 and 1974–75

HONORARY SECRETARIES

	Session
THOMSON, W.	1920–1930
DOREY, S. F.	1930–1931
REED, C. W.	1931–1935
MURRAY, J. M.	1935–1938
PARKER, M. M.	1946–1953
ADAMS, H. J.	1953–1955
HARRISON, R. P.	1955–1957
DAVIES, J. B.	1957–1959
STOOT, W. F.	1959–1960
DEARDEN, C.	1960–1961
HOOK, R. J.	1961–1963
ATKINSON, F. H.	1963–1966
CRIGHTON, L. J.	1966–1968
LISMER, R. E.	1968–1969
SWIATECKI, T.	1969–1972
CUMMINS, C.	1972–1974
WARDLE, A.	1974–1975

TABLE OF PRINCIPAL HEADINGS

	Page
AIRCRAFT	3
BOILERS	3
CARGOES	3
CLASSIFICATION	3
COMPUTERS	3
CORROSION	3
DOCKS AND DOCKING	3
ELECTRICAL MACHINERY	3
ENGINES (Electric)	3
(Internal Combustion)	3
(Steam Reciprocating)	3
(Turbine)	3
(General)	3
FIRE	3
GEARING	3
HISTORY	4
INDUSTRIAL SERVICES	4
INTERNATIONAL CONVENTIONS	4
MARINE ENGINEERING ... ... (Main and Auxiliary Machinery)	4
MATERIALS	4
MISCELLANEOUS	4
NON-DESTRUCTIVE TESTING	4
NUCLEAR ENGINEERING	4
PIPES AND TUBES	5
PROPELLERS	5
PUMPING AND PIPING	5
REFRIGERATION	5
REMOTE CONTROL ENGINEERING	5
REPAIRS (Ship and Machinery)	5
RESISTANCE OF SHIPS	5
SAFETY OF LIFE AT SEA	5
SHAFTING	5
SHIP BUILDING	5
SHIP DESIGN	5
SHIP EQUIPMENT	6
SHIP TYPES	6
STABILITY	6
STEERING GEAR	6
STRENGTH OF MATERIALS	6
SURVEYS (Machinery)	6
(Ship)	6
TECHNICAL INVESTIGATIONS	6
TECHNICAL RECORDS	6
TONNAGE	6
VIBRATION	7
WELDING	7
YACHTS	7

SUBJECT INDEX

Title	Author	Session
AIRCRAFT		
General Notes on the Inspection of Aircraft	Hill, A. J.	1931–32
Notes on the Operation and Maintenance of Commercial Aircraft	Miles, G. H. M.	1932–33
The Problems of Lift and Stability in Aeroplane Design	Handley-Page, F.	1930–31
Some Technical Aspects of the Commercial Airship	Wallis, B. N.	1925–26
BOILERS		
Boiler Explosions	McAfee, J.	1950–51
Boiler Surveys and Repairs ...	Ewing, A.	1928–29
Corrugated Furnaces for Marine Boilers	Roberts, W. H.	1927–28
Notes on Boiler Air Receiver and Shafting Calculations, Part I: Boilers and Air Receivers ...	Blacklock, W.	1953–4–5
Notes on the Survey of Water Tube Boilers	Bedford, C. A.	1946–47
Pulverised Fuel and its Particular Application to Marine Boilers ...	Woodeson, E. W.	1928–29
CARGOES		
The Carriage of Liquefied Petroleum and Natural Gases	Davies, J. B.	1961–62
The Carriage of Timber in the Baltic	Rosen, Jac. V.	1926–27
Fruit and Chilled Cargoes from Australian Ports	Cartwright, E. L.	1934–35
Some Notes on Deep Tanks for Edible Oil and Similar Cargoes ...	Wormald, J.	1949–50
Notes on Edible Oil Quantity Surveys	Kilgour, V. L.	1958–59
Some Further Notes on the Carriage of Liquefied Gases	Atkinson, F. H., *and* Sumner, S.	1967–68
Problems of the Carriage of Perishable Cargoes by Sea	Duly, C. J.	1931–32
Transport of Petroleum by Sea ...	Zulver, C.	1933–34
CLASSIFICATION		
Classification Procedure	Sladden, R. J.	1947–48
Classification Procedures	Algate, C. F.	1969–70
Classification and Seaworthiness ...	Ives, B. J.	1924–25
Lloyd's Register of Shipping's relations with IMCO and IACS ...	Harrison, R. P.	1973–74
The Relationship Between Ship Classification and Marine Underwriting: With Comments on the Adjustment of Average Claims ...	Derby, W. L. A.	1965–66
COMPUTERS		
Application of On-line Computers in Ships	Hancock, J.	1970–71
The Computer and Its Application to Lloyd's Register	Batten, B. K.	1967–68
Data Processing at Lloyd's Register	Browne, A. J.	1972–73
CORROSION		
Corrosion	Pickworth, A.	1922–23
Corrosion Control	Clemmetsen, O. M.	1964–65
Corrosion and Corrosion Prevention in Metals	Lismer, R. E.	1955–6–7
The Joint Action of Fatigue and Corrosion	Urwin, A.	1929–30
Marine Corrosion	Murray, J. M.	1952–53
Some Notes on Wastage and Corrosion	Bennett, W.	1925–26
Steels Available for Marine Engineering and Shipbuilding with Special Reference to the Question of Corrosion	Hatfield, W. H.	1922–23
DOCKS		
Docking: Stresses and Stability ...	Bryden, S. T.	1928–29
Floating Docks	Webster, G.	1920–21
ELECTRICAL MACHINERY		
Alternating or Direct Current on Shipboard	Jaffrey, J. A.	1951–52
Electrical Fittings on Ships	Badger, W. T.	1923–24
The Electrical Layout of Cargo Liners	Brand, S. D.	1948–49
Manufacture, Survey and Testing of Electrical Equipment	Watson, G. O.	1936–37
Ships Electrical Installations and Their Surveys	De Jong, W.	1970–71
Simplified Short Circuit Calculations for Marine Alternating Current Networks	Morris, K., *and* Klemm, K. H.	1970–71
The Survey and Testing of Marine Electrical Equipment	Morris, W.	1961–62
The Survey of Electrical Equipment	Auterson, G., Clayton, R. C., *and* Haffner, H.	1938–39
ENGINES		
(Electric)		
Electric Propulsion of Ships ...	Horne, L. R.	1931–32
The Electric Propulsion of Vessels by Synchronous Motors	Butler, W.	1922–23
Turbo-Electric Installation	Hills, R. M.	1951–52
(Internal Combustion)		
Diesel Engine Design	Anderson, J.	1927–28
The Doxford Opposed Piston Airless Engine	Harbottle, J.	1928–29
Development of the Four Stroke Cycle Marine Diesel Engine ...	McCririck, H.	1927–28
Internal Combustion Engines ...	Hunter, C.	1920–21
Some Notes on Free Piston Gas Turbine Machinery for Marine Applications	Hook, R. J.	1960–61
(Steam Reciprocating)		
The Machinery of the *Great Eastern*	Guthrie, J.	1961–62
(Turbine)		
Stabilizing Turbine Rotors	Horne, L. R.	1951–52
Types of Gas Turbine Plant Available for Marine Application ...	McLeod, N.	1947–48
(General)		
Marine Engines from the Superintendent's Point of View ...	Freeman, S. B.	1934–35
FIRE		
Fire Detection in Unattended Machinery Spaces	Bolding, J. D.	1970–71
Fire Protection, Detection and Extinction in Ships	Coggon, G.	1974–75
GEARING		
Gearing	Teasdale, L.	1959–60

HISTORY

Title	Author	Session
Freak Ships of the XIXth Century	GUTHRIE, J.	1966–67
Some Historical Records and Reminiscences relating to the British Navy and Mercantile Shipping ...	JORDAN, C. H.	1924–25
Lloyd's Register's Activities in Post-War Germany	WALBURN, D. R.	1957–58
Notes and Anecdotes on the Society's Staff during the Victorian Era	SLADDEN, R. J.	1948–49
With the Staff of Lloyd's Register in the 19th Century	SLADDEN, R. J.	1934–35

INDUSTRIAL SERVICES

Title	Author	Session
Some Notes on Non-Marine Work	SAVOURS, J. L.	1969–70

INTERNATIONAL CONVENTIONS

Title	Author	Session
The History of British Freeboard Regulations	WATT, W.	1923–24
The History of British Freeboard Regulations 1922–1930	WATT, W.	1930–31
The International Conference on Marine Pollution, 1973 and resulting International Convention ...	HARRISON, R. P., ATKINSON, F. H., *and* DOBSON, R. J. C.	1973–74
The 1948 International Convention on Safety of Life at Sea	BRYDEN, S. T., BEVERIDGE, J. R., *and* WATSON, G. O.	1949–50
1966 Load Line Convention: Its Implications and Interpretations	SIMPSON, T. A., BATES, J. M., *and* BECKWITH, L.	1969–70
The Survey of Safety Equipment ...	MACMILLAN, W.	1957–58
The Survey of Safety Equipment in Cargo Ships	SMART, G.	1970–71

MARINE ENGINEERING
(Main and Auxiliary Machinery)

Title	Author	Session
Alignment in Marine Engines: Part I: Turbines to Pinions	HILDREW, B.	1952–53
Alignment of Marine Engines: Part II: Shafting	HILDREW, B.	1955–6–7
Some Comments on Shafting and Sterntubes	BERGMANN, C. M.	1971–72
Compressors	SDOROWOK, V. F. J.	1934–35
Some Early Marine Engineering Experiences and Practice	SMITH, E. C.	1935–36
Lloyd's Register and the Marine Engine Builder	SCHIFF, A.	1974–75
Marine Steam Turbines	DONALD, K. M. B.	1971–72
Some Notes on Auxiliary Machinery	BROWN, P. T.	1924–25
Some Notes on a Large Tanker Machinery Installation	HAGUE, D.	1972–73
Recent Developments in Marine Engineering in Germany ...	WITT, C. F. M.	1930–31

MATERIALS

Title	Author	Session
The Effect of Metallurgical Variables on the Brittle Fracture of Mild and Medium Carbon Steels ...	NAYSMITH, J.	1965–66
Forging Practice	ROBERTSON, M.	1920–21
Glass—A Short Account of the Development of Its Manufacture, and some of Its Properties ...	INGLEBY, J. H.	1965–66
The Heat Treatment of Steel ...	PATCHIN, G.	1923–24
Inspection of Materials in the Prague District	KERTSCHER, P.	1931–32
The Inspection of Pre-stressed Concrete Beams	PRIEST, E. W.	1966–67
The Manufacture and Heat Treatment of Steel Forgings	PORTER, C. S.	1934–35
Manufacture of Iron and Steel Forgings	FLETCHER, A.	1921–22
Model Structural Testing Techniques	WORDSWORTH, A. C.	1970–71
Modern Foundry Practice	BUSHELL, T. W.	1950–51
Some Notes on New Processes and Alloys in Cast Metals	COWIE, W.	1928–29
Notes on the Manufacture and Testing of Shipbuilding Materials in the United States	GROVE, J. M.	1948–49
Recent Developments in Steel Making Practice	LISTON, R.	1962–63
Some Observations on Steel Founding	RIPLEY, L.	1924–25
Remarks on Castings	MILTON, J. T.	1923–24
Steel Testing	HECK, W. D., *and* ROBERTSON, J. F.	1922–23
Steel Testing on the Occasional Attendance System ...	KOLBOW, H.	1924–25
Tensile Testing of Steel	LISTON, R., *and* HUSKINS, J. C.	1968–69
Timbers: Their Characteristics, Preparation and Use in Ships, Yacht and Boats	BLOCKSIDGE, E. W.	1927–28

MISCELLANEOUS

Title	Author	Session
Bizarre Craft of Portugal	GUTHRIE, J.	1947–48
"Brazil"	SLATER, I. G.	1960–61
Some Developments in the Ministry of Defence	RAWSON, K. J.	1970–71
Flying over Mount Everest ...	BLACKER, L. V. S.	1934–35
The Future of the Society	KNOWLES, W. C. G.	1968–69
The Measurements of Exceedingly Large and Extremely Small Quantities	MILTON, J. T.	1920–21
Notes on Foreign Service	SOUTHWELL, H. P.	1948–49
Notes on Insurance	STURGE, A. L.	1932–33
The Oxford University Arctic Expedition North East Land, 1935–36	MACKENZIE, A. D.	1938–39
The Printing House	ROWELL, E. W.	1972–73
Public Relations	DANIEL, R. D.	1972–73
Recent Developments of Wireless Telegraphy	MARCHANT, A. W.	1921–22
Russian Higher Technological Education in Industry	SLATER, I. G.	1959–60
Scientific Study of Sea Power ...	ABELL, SIR W. S.	1921–22
Shipping as a Means of Livelihood	ESSENDON, THE RT. HON. LORD	1937–38
Technical Training and Information	STOOT, W. F., *and* SWIATECKI, T.	1969–70
The Work of the Port of London Authority	RICHARDSON, J.	1973–74
Work of the Staff Department ...	VENNER, E. W.	1968–69

NON-DESTRUCTIVE TESTING

Title	Author	Session
Electric Resistance Strain Gauges ...	COGMAN, A. J.	1953–4–5
Quality Control	BROWN, E. A.	1967–68
Radiographic Inspection	COCKS, F. C., *and* PEMBERTON, H. N.	1947–48
Strain Gauge Technique	COGMAN, A. J.	1963–64

NUCLEAR ENGINEERING

Title	Author	Session
The Design and Classification of a Nuclear Powered Ship	MCCALLUM, J.	1960–61
Nuclear Energy—Its Source and Its Application to Marine Engineering	HILDREW, B.	1960–61

PIPES AND TUBES

Title	Author	Session
Seamless Steel Tubes	CHAMPNESS, G. T.	1936–37
Solid Drawn Steel Tubes and Air Receivers	PRINGLE, J.	1934–35
Steam Pipes in Marine Practice	DAVIS, L. C.	1929–30
Steel Tubes: Manufacture and Some Uses	CAMPBELL, F., *and* McFARLANE, G.	1952–53

PROPELLERS

Title	Author	Session
Propellers	McCRIRICK, H.	1934–35

PUMPING AND PIPING

Title	Author	Session
Pumping Arrangements	BEVERIDGE, J. R.	1938–39
Pumping and Piping Arrangements	CLAYTON, H. R.	1959–60
The Storage and Transfer of Liquid Fuel in Ships	DAVIS, L. C.	1921–22

REFRIGERATION

Title	Author	Session
Classed Refrigerated Installations	COLES, P. K.	1971–72
Refrigeration	GEMMELL, D.	1937–38
Refrigerating Stores and their Equipment	GEMMELL, D.	1930–31
Some Notes on Refrigeration	TOWNEND, S.	1925–26
The Storage of Refrigerated Cargo on Board Vessels	GORDON, J. S.	1924–25

REMOTE CONTROL ENGINEERING

Title	Author	Session
Behaviour of Control Equipment in a Steam Turbine Tanker	GRAY, D.	1969–70
Control Dynamics	LARSEN, K.	1968–69
First Steps in Control Engineering Made Easy	HINSON, A. R.	1968–69
Indicating and Recording Instruments	HUBBARD, G. S.	1968–69

REPAIRS

(Ship and Machinery)

Title	Author	Session
Deterioration and Repairs of Steel Ships	MACDONALD, J.	1921–22
Ice Navigation and Damage in the Baltic	THOMSON, H. J.	1924–25
Marine Engine Repairs	GUTHRIE, J.	1959–60
Some Machinery Repairs	GIBBESON, T. P.	1949–50
A Symposia:		
Novel Repairs and Unusual Features		1931–32
Novel Repairs and Unusual Features		1932–33
Novel Repairs and Unusual Features		1933–34
Repairs to Machinery	CAMPBELL, A.	1922–23
Ship Repairs at Lisbon	DIXON, G.	1947–48
Temporary Hull Repairs to the Tanker *Markay*	REID, A.	1946–47
Temporary Repairs	CAIRNS, R. D.	1923–24

RESISTANCE OF SHIPS

Title	Author	Session
The Development of Hull Form	CONN, J. F. C.	1936–37
The National Experimental Tank	BAKER, C. S.	1927–28

SHAFTING

Title	Author	Session
Crank Shafts	CLARKE, H.	1921–22
Notes on Tail Shafts	WATT, A.	1948–49
Shafting Calculations	BLACKLOCK, W.	1955–6–7

SHIP BUILDING

Title	Author	Session
Aluminium in Shipbuilding	HARRISON, R. P.	1955–6–7
Caulking	BARTLETT, C.	1931–32
Some Considerations Favouring Metal in the Construction of Small Hulls	WALSH, J. V.	1957–58
Electric Welding as Seen by the Outport Member	AKESTER, A. G.	1932–33
Electric Welding in German Shipbuilding	SHEPHEARD, R. B.	1955–6–7
Hatchways	BUCHANAN, J. G.	1936–37
Hull Damage in Large Ships	JANZEN, S., *and* NILLSON, O.	1972–73
Joining Ships Afloat	SCHEELINGS, W. B.	1968–69
Lloyd's Register and the Shipbuilder	BELCH, A. R.	1973–74
Marking Off and Erecting in Trieste District	CONSTANTINI, M.	1922–23
Merchant Shipbuilding in Australia	MILLAR, W. C.	1949–50
Some Notes on Plating and Riveting	LANGLANDS, R.	1920–21
Notes on Welding in Swedish Shipbuilding	ADAMS, H. J.	1947–48
Some Notes on the Construction and Details of the Welded Oil Tanker *Helicina*	DEAN, E. H.	1946–47
Ship Welding and the Influence of Residual Stresses	STOCKS, C. H., *and* THURSTON, J. W. G.	1946–47
Ocean Type Vessels—Some Notes on Bottom Stiffening and Welding Procedure	RONALD, W.	1949–50
The Practical Construction of Oil Tankers	MACDONALD, J.	1930–31
Recent Developments in Oil Ship Construction	THOMSON, H.	1920–21
Some Recent Developments in Swedish Shipbuilding	SARGINSON, J. R.	1958–59
Remarks on Shipbuilding Practice	JACKSON, A. W.	1937–38
Shipbuilding as a Means of Livelihood	LITHGOW, SIR JAMES, BT.	1935–36
Sub-Division of Ships	JOHNSON, R. S.	1924–25

SHIP DESIGN

Title	Author	Session
The Basis of Hull Strength	EDGAR, G. R.	1926–27
Buckling as a Mode of Failure in Ship Structures	MATHEWSON, J. I., *and* VINER, A. C.	1970–71
Comparative Stresses in Oil and Cargo Ships	THOMSON, W.	1921–22
The Effect of Beam Knees on the Transverse Strength of Vessels	AKESTER, A. G.	1922–23
Estimation of Ship Motions and Longitudinal Bending Moments	GOODMAN, R. A.	1966–67
Icebreakers, Their Design and Construction	CRIGHTON, L. R.	1964–65
The Influence of Design on Longitudinal Bending Moments in Cargo Ships	FRASER-SMITH, F. D., *and* SALISBURY, P. R.	1955–6–7
Lessons from Welded Ships Structural Failures and Repairs	KENNEDY, A. M.	1950–51
Longitudinal Stresses in Modern Canadian Great Lakes Bulk Freighters	McKINLEY, F. S. J.	1963–64
Longitudinal Stresses in Ships	MURRAY, J. M.	1961–62
The New Approach to Longitudinal Strength	MURRAY, J. M.	1961–62
Some Notes on Ship Plan Approval	CLEMMETSEN, O. M.	1962–63
Notes on Strength of Ships	ORMISTON, J. S.	1923–24
Recent Development in Cargo Ship Design	ADAMS, H. J.	1953–4–5
Rudders and Sternframes	LAST, F. B.	1957–58

Title	Author	Session
The Structural Design of Fixed and Steerable Propeller Ducts	BARTON, R. F.	1973–74
Structural Problems in Ships with Large Hatch Openings	DE WILDE, IR. G.	1966–67
Strength of Ships	BALFOUR, W. M.	1933–34
Symposia: Some Interesting and Unusual Features of Ship Design, Construction and Repair		1962–63

SHIP EQUIPMENT

Title	Author	Session
Anchoring and Mooring	BUCKLE, A. K.	1971–72
Chain Cables and Their Testing ...	HECK, W. D.	1938–39
Ships' Cargo Handling Gear ...	BECKWITH, L.	1962–63
Use of Fork Lift Trucks	SMITH, W. S.	1962–63

SHIP TYPES

Title	Author	Session
Air Cushion Vehicles	BUCKLE, A. K.	1966–67
Cable Ships	FINDLAY, A.	1959–60
Coasting Vessels	SHEPHEARD, R. B.	1929–30
Composite Vessels	LOWSON, J. A.	1930–31
General Notes on Great Lakes Ships	MACBEAN, L. D.	1953–4–5
Great Lakes Bulk Freighters ...	BENNETT, W.	1928–29
Hydrofoils	BUCKLE, A., *and* BEASON, C.	1965–66
Notes on Recent Developments in Large Passenger Ships	TOWNSHEND, S., *and others*	1935–36
(a) Structural, by S. TOWNSHEND		
(b) Propelling Machinery, by R. LEE ANNEAR		
(c) Sub-Division, by S. T. BRYDEN		
(d) Life-Saving Appliances, by E. W. BLOCKSIDGE		
(e) Electrical Equipment, by G. O. WATSON		
(f) Fire Protection, by C. W. REED		
Notes on Various Types of Dredgers and Barges	MACLEOD, M.	1935–36
Notes on Whaling and Its Development	CHRISTENSEN, C. F.	1938–39
The Preparation and Delivery of Unusual Types of Vessels for Overseas Service	PEDDER, F. W.	1929–30
Recent Development in Cargo Ship Design	ADAMS, H. J.	1953–4–5
Refrigerated Liquefied Gas Carriers (Heat Transfer—Cargo Conditioning and Commissioning ...	NAVAZ, M. Z.	1968–69
Three Island Vessels	MURRAY, J. M.	1933–34
Trawling and Drifting	BARTLETT, C., *and* TOWNSHEND, S.	1920–21

STABILITY

Title	Author	Session
The Freeboard Stability and Seaworthiness of Shelter Deck Steamers	WATT, W.	1920–21
Stability and Seaworthiness of the Collier	WATT, W.	1925–26

STEERING GEAR

Title	Author	Session
Steering Gear	BUCHANAN, G.	1936–37
Steering Gear	LOCKHART, R. C.	1963–64
The Steering of Ships	PARKER, M. M.	1924–25

STRENGTH OF MATERIALS

Title	Author	Session
The Behaviour of Metals under Repeated Stresses	LEA, F. C.	1926–27
Behaviour of Steel at Elevated Temperatures	FORSYTH, G. H., *and* REED, C. W.	1932–33
Combined Stresses	DOREY, S. F.	1926–27
Engineering Materials Stressed at Superheat Temperatures	LEWIS, W. E.	1929–30
An Introduction to Fatigue ...	BATTEN, B. K.	1957–58
Lessons to be Learned from the Appearance of Fractures ...	BOYD, G. M.	1951–52
Tensile Testing Machines	MILTON, J. H.	1949–50

SURVEYS

(Machinery)

Title	Author	Session
The Fitting of Machinery on Board Ships	BROWN, P. T.	1931–32
Some Notes on Engine Reports ...	KNOWLES, E. L.	1958–59
Some Notes on the Survey of Diesel Engines	LEE ANNEAR, R.	1926–27
Survey and Testing of Welded Pressure Vessels	SUTHERST, H. L.	1938–39
Survey of Machinery and Boilers During Construction in the Shops	BROWN, P. T.	1934–35
Survey of Mass Production	BROWN, P. T.	1946–47
Surveying in Portugal	GUTHRIE, J.	1951–52

(Ship)

Title	Author	Session
The Essentials in the Survey of Oil Tankers	EDGAR, G. R.	1950–51
Hull Surveys and Where to Look for Defects	MACKECHNIE, H.	1957–58
Indexing and Analysis of Survey Reports	BOYD, G. M., *and* DRUCQUER, S. H.	1948–49
Notes on Special Surveys ...	SHAW, T.	1935–36
The Survey of Crew Accommodation	SMITH, J. R. G., *and* BARROW, J. W.	1970–71
Surveying OBO's and Large Bulk Carriers	MCINTOSH, G. S.	1974–75
Towage Surveys and Associated Work	VAN DUFFELEN, K.	1972–73
Notes on Surveying Duties in Foreign Ports	SMITH, F. G. C.	1933–34
Some Notes on the Hull Survey of New Construction in Sweden	NILSSON, O.	1969–70
Report 8—A Few General Notes ...	TURNER, D.	1953–4–5
Some Remarks Arising from Damage Surveys	NELL, T.	1950–51
Salvage Association Damage Surveys	SEDGWICK, S.	1965–66
Survey and Repair of Old Trawlers	RENNIE, R.	1938–39
The Survey of Rudders	FLETCHER, H. L.	1926–27
Symposia:		
The Survey of Very Old Ships ...		
The Repair of Welded Ships ...		1952–53

TECHNICAL INVESTIGATIONS

Title	Author	Session
Interesting Investigations	MILTON, J. H.	1961–62

TECHNICAL RECORDS

Title	Author	Session
A Brief Guide to the Preparation and Presentation of Technical Papers	CUMMINS, C.	1973–74
Index to the Transactions 1920–1962	HOOK, R. J.	1962–63
Index to the Transactions 1920–1970	HOOK, R. J.	1969–70
Index to the Transactions 1920–1975	HOOK, R. J.	1974–75
Some Early Technical Records of Ship Department	MANLEY, C. V.	1958–59
Lloyd's Register Staff Association: The Past and the Future	DAVIES, J. B., GRAY, D., VENNER, E. W., *and* WARRIS, J. G. F.	1970–71
Technical Records	BOYD, G. M.	1967–68

Title	Author	Session
TONNAGE		
The Register Tonnage of Ships ...	BLOCKSIDGE, E. W.	1923–24
Tonnage	GRAY, R., *and* BECKWITH, L.	1958–59
VIBRATION		
Some Aspects of Propeller Excited Vibration	LAMPLOUGH, T. A.	1961–62
Notes on Vibration Problems ...	HINSON, A. R.	1960–61
Torsional Oscillations in Marine Engine Shafting	DOREY, S. F.	1929–30
Torsional Vibration from the Practical Viewpoint	ARCHER, S.	1951–52
Vibration in Ships	CONSTANTINI, M.	1937–38
WELDING		
Electro-Slag Welding	MORRISON, R.	1963–64
Welding	PEMBERTON, H. N.	1934–35
YACHTS		
The Construction of Wood Yachts	BALFOUR, A. K.	1953–4–5

Title	Author	Session
Forty Years Reminiscences of Yachts and Yachting	HOW, A. P.	1923–24
Glass Reinforced Plastic Boat Building:		
Parts I and II	MCINNES, A.	1962–63
Parts III and IV	MCINNES, A., *and* HOBBS, W. L.	1963–64
Parts V and VI	MCINNES, A.	1964–65
Resin Bonded Wood Laminates in Marine Construction	HOBBS, W. L.	1959–60
Some Notes on the Construction of Wood Ships and Yachts	LOWSON, J. A.	1927–28
Some Notes on the Development and Construction of the American Racing Yacht	BENNETT, W.	1922–23
Some Practical Aspects of Moulding G.R.P. Yachts and Small Craft ...	TYLER, J., *and* MUSTERS, R.	1974–75
Reinforced Plastics	HEDGER, A. J. R.	1957–58
The Survey of Wood Ships and Yachts	SHAW, G. M.	1926–27
Yachts and Yachting in Sweden ...	ISAKSON, A.	1923–24

TITLE INDEX

Title	Author	Session
A		
Air Cushion Vehicles	BUCKLE, A. K.	1966–67
Alignment in Marine Engines: Part I Turbines to Pinions	HILDREW, B.	1952–53
Alignment of Marine Engines: Part II Shafting	HILDREW, B.	1955–6–7
Alternating or Direct Current on Shipboard	JAFFREY, J. A.	1951–52
Aluminium in Shipbuilding	HARRISON, R. P.	1955–6–7
Anchoring and Mooring	BUCKLE, A. K.	1971–72
Application of On-line Computers in Ships	HANCOCK, J.	1970–71
Some Aspects of Propeller Excited Vibration	LAMPLOUGH, T. A.	1961–62
B		
The Basis of Hull Strength	EDGAR, G. R.	1926–27
Behaviour of Control Equipment in a Steam Turbine Tanker	GRAY, D.	1969–70
The Behaviour of Metals under Repeated Stresses	LEA, F. C.	1926–27
Behaviour of Steel at Elevated Temperatures	FORSYTH, G. H., *and* REED, C. W.	1932–33
Bizarre Craft of Portugal	GUTHRIE, J.	1947–48
Boiler Explosions	MCAFEE, J.	1950–51
Boiler Surveys and Repairs	EWING, A.	1928–29
"Brazil"	SLATER, I. G.	1960–61
A Brief Guide to the Preparation and Presentation of Technical Papers ...	CUMMINS, C.	1973–74
Buckling as a Mode of Failure in Ship Structures	MATHEWSON, J. I., *and* VINER, A. C.	1970–71
C		
Cable Ships	FINDLAY, A.	1959–60
The Carriage of Liquefied Petroleum and Natural Gases	DAVIES, J. B.	1961–62
The Carriage of Timber in the Baltic	ROSEN, JAC. V.	1926–27
Caulking	BARTLETT, C.	1931–32
Chain Cables and Their Testing ...	HECK, W. D.	1938–39
13% Chromium Steel Water Turbine Castings in Switzerland and Their Repair by Welding	MUNRO, R. F.	1964–65
Classed Refrigerated Installations ...	COLES, P. K.	1971–72
Classification Procedure	SLADDEN, R. J.	1947–48
Classification Procedures	ALGATE, C. F.	1969–70
Classification and Seaworthiness ...	IVES, B. J.	1924–25
Coasting Vessels	SHEPHEARD, R. B.	1929–30
Combined Stresses	DOREY, S. F.	1926–27
Some Comments on Shafting and Sterntubes	DONALD, K. M. B.	1971–72
Comparative Stresses in Oil and Cargo Ships	THOMSON, W.	1921–22
Composite Vessels	LOWSON, J. A.	1930–31
Compressors	SDOROWOK, V. F. J.	1934–35
The Computer and Its Application to Lloyd's Register	BATTEN, B. K.	1967–68
Some Considerations Favouring Metal in the Construction of Small Hulls	WALSH, J. V.	1957–58
The Construction of Wood Yachts ...	BALFOUR, A. K.	1953–4–5
Control Dynamics	LARSEN, K.	1968–69
Corrosion	PICKWORTH, A.	1922–23
Corrosion Control	CLEMMETSEN, O. M.	1964–65
Control and Corrosion Prevention in Metals	LISMER, R. E.	1955–6–7
Corrugated Furnaces for Marine Boilers	ROBERTS, W. H.	1927–28
Crank Shafts	CLARKE, H.	1921–22
D		
Data Processing at Lloyd's Register ...	BROWNE, A. J.	1972–73
The Design and Classification of a Nuclear Powered Ship	MCCALLUM, J.	1960–61
Deterioration and Repairs of Steel Ships	MACDONALD, J.	1921–22
The Development of Hull Form ...	CONN, J. F. C.	1936–37
Development of the Four Stroke Cycle Marine Diesel Engine	MCCRIRICK, H.	1927–28
Developments in Carbon Steels ...	LISMER, R. E.	1963–64
Some Developments in the Ministry of Defence	RAWSON, K. J.	1970–71
Diesel Engine Design	ANDERSON, J.	1927–28
Docking: Stresses and Stability ...	BRYDEN, S. T.	1928–29
The Doxford Opposed Piston Airless Engine	HARBOTTLE, J.	1928–29
E		
Some Early Marine Engineering Experiences and Practice	SMITH, E. C.	1935–36
Some Early Technical Records of Ship Department	MANLEY, C. V.	1958–59
The Effect of Beam Knees on the Transverse Strength of Vessels ...	AKESTER, A. G.	1922–23
The Effect of Metallurgical Variables on the Brittle Fracture of Mild and Medium Carbon Steels ...	NAYSMITH, J.	1965–66
Electrical Fittings on Ships	BADGER, W. T.	1923–24
The Electrical Layout of Cargo Liners	BRAND, S. D.	1948–49
Electric Welding as seen by the Outport Member	AKESTER, A. G.	1932–33
Electric Propulsion of Ships	HORNE, L. R.	1931–32
The Electric Propulsion of Vessels by Synchronous Motors	BUTLER, W.	1922–23
Electric Resistance Strain Gauges ...	COGMAN, A.	1953–4–5
Electric Welding in German Shipbuilding	SHEPHEARD, R. B.	1937–38
Electro-Slag Welding	MORRISON, R.	1963–64
Engineering Materials Stressed at Superheat Temperatures	LEWIS, W. E.	1929–30
The Essentials in the Survey of Oil Tankers	EDGAR, G. R.	1950–51
Estimation of Ship Motions and Longitudinal Bending Moments	GOODMAN, R. A.	1966–67
Fire Detection in Unattended Machinery Spaces	BOLDING, J. D.	1970–71
Fire Protection, Detection and Extinction in Ships	COGGON, G.	1974–75
F		
First Steps in Control Engineering Made Easy	HINSON, A. R.	1968–69
The Fitting of Machinery on Board Ships	BROWN, P. T.	1931–32
Floating Docks	WEBSTER, G.	1920–21
Flying over Mount Everest	BLACKER, L. V. S.	1934–35
Forging Practice	ROBERTSON, M.	1920–21
Forty Years Reminiscences of Yachts and Yachting	HOW, A. P.	1923–24
Freak Ships of the XIXth Century ...	GUTHRIE, J.	1966–67

Title	Author	Session
The Freeboard, Stability and Seaworthiness of Shelter Deck Steamers	WATT, W.	1920–21
Fruit and Chilled Cargoes from Australian Ports ...	CARTWRIGHT, E. L.	1934–35
The Future of the Society ...	KNOWLES, W. C. G.	1968–69
G		
Gearing ...	TEASDALE, L.	1959–60
General Notes on Great Lake Ships ...	MACBEAN, L. D.	1953–4–5
General Notes on the Inspection of Aircraft ...	HILL, L. J.	1931–32
Glass—A Short Account of the Development of its Manufacture, and some of its Properties ...	INGLEBY, J. H.	1965–66
Glass Reinforced Plastic Boat Building: Parts I and II ...	MCINNES, A.	1962–63
Glass Reinforced Plastic Boat Building: Parts III and IV ...	MCINNES, A., *and* HOBBS, W. L.	1963–64
Glass Reinforced Plastic Boat Building: Parts V and VI ...	MCINNES, A.	1964–65
Great Lakes Bulk Freighters ...	BENNETT, W.	1928–29
H		
Hatchways ...	BUCHANAN, J. G.	1936–37
The Heat Treatment of Steel ...	PATCHIN, G.	1923–24
Some Historical Records and Reminiscences relating to the British Navy and Mercantile Shipping ...	JORDAN, C. H.	1924–25
The History of British Freeboard Regulations ...	WATT, W.	1923–24
The History of British Freeboard Regulations ...	WATT, W.	1930–31
Hull Damage in Large Ships ...	JANZEN, S., *and* NILSSON, O.	1972–73
Hull Surveys and Where to Look for Defects ...	MACKECHNIE, H.	1957–58
Hydrofoils ...	BUCKLE, A., *and* BEASON, C.	1965–66
I		
Icebreakers, Their Design and Construction ...	CRIGHTON, L. J.	1964–65
Ice Navigation and Damage in the Baltic ...	THOMSON, H. J.	1924–25
Indexing and Analysis of Survey Reports ...	BOYD, G. M., *and* DRUCQUER, S. H.	1948–49
Index to the Transactions 1920–1962	HOOK, R. J.	1962–63
Index to the Transactions 1920–1970	HOOK, R. J.	1969–70
Index to the Transactions 1920–1973	HOOK, R. J.	1974–75
Indicating and Recording Instruments	HUBBARD, G. S.	1968–69
The Influence of Design on Longitudinal Bending Moments in Cargo Ships ...	FRASER-SMITH, F. D., *and* SALISBURY, P. R.	1955–6–7
Inspection of Materials in the Prague District ...	KERTSCHER, P.	1931–32
The Inspection of Pre-Stressed Concrete Beams ...	PRIEST, E. W.	1966–67
Interesting Investigations ...	MILTON, J. H.	1961–62
Internal Combustion Engines ...	HUNTER, C.	1920–21
The International Conference on Marine Pollution, 1973 and resulting International Convention ...	HARRISON, R. P., ATKINSON, F. H., *and* DOBSON, R. J. C.	1973–74

Title	Author	Session
The 1948 International Convention on Safety of Life at Sea ...	BRYDEN, S. T., BEVERIDGE, J. R., *and* WATSON, G. O.	1949–50
An Introduction to Fatigue ...	BATTEN, B. K.	1957–58
J		
Joining Ships Afloat ...	SCHEELINGS, W. B.	1968–69
The Joint Action of Fatigue and Corrosion ...	URWIN, A.	1929–30
L		
Lessons from Welded Ships Structural Failures and Repairs ...	KENNEDY, A. M.	1950–51
Lessons to be learned from the Appearance of Fractures ...	BOYD, G. M.	1951–52
Lloyd's Register and the Marine Engine Builder ...	SCHIFF, A.	1974–75
Lloyd's Register and the Shipbuilder	BELCH, A. R.	1973–74
Lloyd's Register of Shipping's relations with IMCO and IACS ...	HARRRISON, R. P.	1973–74
Lloyd's Register Staff Association: The Past and the Future ...	DAVIES, J. B., GRAY, D., VENNER, E. W., *and* WARRIS, J. G. F.	1970–71
Lloyd's Register's Activities in Post-war Germany ...	WALBURN, D. R.	1957–58
1966 Load Line Convention: Its Implications and Interpretations ...	SIMPSON, T. A., BATES, J. M., *and* BECKWITH, L.	1969–70
Longitudinal Stresses in Modern Canadian Great Lakes Bulk Freighters ...	MCKINLEY, F. S. J.	1963–64
Longitudinal Stresses in Ships ...	MURRAY, J. M.	1951–52
M		
Some Machinery Repairs ...	GIBBESON, T. P.	1949–50
The Machinery of the *Great Eastern*	GUTHRIE, J.	1961–62
Manufacture, Survey and Testing of Electrical Equipment ...	WATSON, G. O.	1936–37
The Manufacture and Heat Treatment of Steel Forgings ...	PORTER, C. S.	1934–35
Manufacture of Iron and Steel Forgings ...	FLETCHER, A.	1921–22
Marine Corrosion ...	MURRAY, J. M.	1952–53
Marine Engine Repairs ...	GUTHRIE, J.	1959–60
Marine Engines from the Superintendent's Point of View ...	FREEMAN, S. B.	1934–35
Marking off and Erecting in Trieste District ...	CONSTANTINI, M.	1922–23
The Measurements of Exceedingly Large and Extremely Small Quantities ...	MILTON, J. T.	1920–21
Merchant Shipbuilding in Australia ...	MILLAR, W. C.	1949–50
Model Structural Testing Techniques	WORDSWORTH, A. C.	1970–71
Modern Foundry Practice ...	BUSHELL, T. W.	1950–51
N		
The National Experimental Tank ...	BAKER, G. S.	1927–28
The New Approach to Longitudinal Strength ...	MURRAY, J. M.	1961–62
Some Notes on a Large Tanker Machinery Installation ...	HAGUE, D.	1972–73
Some Notes on Auxiliary Machinery	BROWN, P. T.	1924–25

Title	*Author*	*Session*
Notes on Boiler, Air Receiver and Shafting Calculations. Part I: Boilers and Air Receivers	BLACKLOCK, W.	1953–4–5
Some Notes on Deep Tanks for Edible Oil and Similar Cargoes	WORMALD, J.	1949–50
Notes on Edible Oil Quantity Surveys	KILGOUR, V. L.	1958–59
Some Notes on Engine Reports ...	KNOWLES, E. L.	1958–59
Notes on Foreign Service	SOUTHWELL, H. P.	1948–49
Some Notes on Free Piston Gas Turbine Machinery for Marine Applications	HOOK, R. J.	1960–61
Notes on Insurance	STURGE, A. L.	1932–33
Some Notes on New Processes and Alloys in Cast Metals	COWIE, W.	1928–29
Some Notes on Non-Marine Work ...	SAVOURS, J. L.	1969–70
Some Notes on Plating and Riveting	LANGLANDS, R.	1920–21
Notes on Recent Developments in Large Passenger Ships	TOWNSHEND, S., *and others*	1935–36
(a) Structural, by S. TOWNSHEND ...		
(b) Propelling Machinery, by R. LEE ANNEAR		
(c) Sub-division, by S. T. BRYDEN ...		
(d) Life-saving Appliances, by E. W. BLOCKSIDGE ...		
(e) Electrical Equipment, by G. O. WATSON		
(f) Fire Protection, by C. W. REED		
Some Notes on Refrigeration	TOWNEND, S.	1925–26
Some Notes on Ship Plan Approval ...	CLEMMETSEN, O. M.	1962–63
Notes on Special Surveys	SHAW, T.	1935–36
Notes on Strength of Ships	ORMISTON, J. S.	1923–24
Notes on Surveying Duties in Foreign Ports	SMITH, F. G. B.	1933–34
Notes on Tail Shafts	WATT, A.	1948–49
Notes on Various Types of Dredgers and Barges	MACLEOD, M.	1935–36
Notes on Vibration Problems ...	HINSON, A. R.	1960–61
Some Notes on Wastage and Corrosion	BENNETT, W.	1925–26
Notes on Welding in Swedish Ship-building	ADAMS, H. J.	1947–48
Notes on Whaling and Its Development	CHRISTENSEN, C. F.	1938–39
Some Notes on Writing Damage Reports	PHILLIP, L. D.	1974–75
Some Further Notes on the Carriage of Liquefied Gases	ATKINSON, F. H., *and* SUMMER, S.	1967–68
Some Notes on the Construction and Details of the Welded Oil Tanker *Helicina*	DEAN, E. H.	1946–47
Somes Notes on the Construction of Wood Ships and Yachts	LOWSON, J. A.	1927–28
Some Notes on the Development and Construction of the American Racing Yacht	BENNETT, W.	1922–23
Some Notes on the Hull Survey of New Construction in Sweden ...	NILSSON, O.	1969–70
Notes on the Manufacture and Testing of Shipbuilding Materials in the United States	GROVE, J. M.	1948–49
Notes on the Operation and Maintenance of Commercial Aircraft ...	MILES, G. H. M.	1932–33
Some Notes on the Survey of Diesel Engines	LEE ANNEAR, R.	1926–27
Notes on the Survey of Water Tube Boilers	BEDFORD, C. A.	1946–47
Notes and Anecdotes on the Society's Staff During the Victorian Era ...	SLADDEN, R. J.	1948–49
Nuclear Energy—Its Source and Its Application to Marine Engineering	HILDREW, B.	1960–61

O

Title	*Author*	*Session*
Some Observations on Steel Founding	RIPLEY, L.	1924–25
Ocean Type Vessels—Some Notes on Bottom Stiffening and Welding Procedure	RONALD, W.	1949–50
The Oxford University Arctic Expedition North East Land, 1935–1936 ...	MACKENZIE, A. D.	1938–39

P

Title	*Author*	*Session*
Some Practical Aspects of Moulding G.R.P. Yachts and Small Craft ...	TYLER, J., *and* MUSTERS, R.	1974–75
The Practical Construction of Oil Tankers	MACDONALD, J.	1930–31
The Preparation and Delivery of Unusual Types of Vessels for Overseas Service	PEDDER, F. W.	1929–30
The Printing House	ROWELL, E. W.	1972–73
The Problems of Lift and Stability in Aeroplane Design	HANDLEY-PAGE, F.	1930–31
Problems of the Carriage of Perishable Cargoes by Sea	DULY, C. J.	1931–32
Propellers	MCCRIRICK, H.	1934–35
Public Relations	DANIEL, R. D.	1972–73
Pulverised Fuel and its Particular Application to Marine Boilers ...	WOODESON, E. W.	1928–29
Pumping Arrangements	BEVERIDGE, J. R.	1938–39
Pumping and Piping Arrangements ...	CLAYTON, H. R.	1959–60

Q

Title	*Author*	*Session*
Quality Control	BROWN, E. A.	1967–68

R

Title	*Author*	*Session*
Radiographic Inspection	COCKS, F. C., *and* PEMBERTON, H. N.	1947–48
Recent Development in Cargo Ship Design	ADAMS, H. J.	1953–4–5
Recent Developments in Marine Engineering in Germany	WITT, F. C. M.	1930–31
Recent Developments in Oil Ship Construction	THOMSON, H.	1920–21
Recent Developments in Steel Making Practice	LISTON, R.	1962–63
Some Recent Developments in Swedish Shipbuilding	SARGINSON, J. R.	1958–59
Recent Developments of Wireless Telegraphy	MARCHANT, A. W.	1921–22
Refrigerated Liquefied Gas Carriers (Heat Transfer—Cargo Conditioning and Commissioning) ...	NAVAZ, M. Z.	1968–69
Refrigeration	GEMMELL, D.	1937–38
Refrigerating Stores and Their Equipment	GEMMELL, D.	1930–31
The Register Tonnage of Ships ...	BLOCKSIDGE, E. W.	1923–24
Reinforced Plastics	HEDGER, A. J. W.	1957–58
The Relationship between Ship Classification and Marine Underwriting: With Comments on the Adjustment of Average Claims	DERBY, W. L. A.	1965–66
Some Remarks Arising from Damage Surveys	NELL, T.	1950–51
Remarks on Castings	MILTON, J. T.	1923–24
Remarks on Shipbuilding Practice ...	JACKSON, A. W.	1937–38
Repairs to Machinery	CAMPBELL, A.	1922–23
Report 8—A Few General Notes ...	TURNER, D.	1953–4–5

Title	*Author*	*Session*
Resin Bonded Wood Laminates in Marine Construction	HOBBS, W. L.	1959–60
Rudders and Sternframes	LAST, F. B.	1957–58
Russian Higher Technological Education and Industry	SLATER, I. G.	1959–60
S		
Salvage Association Damage Surveys	SEDGWICK, S.	1965–66
Scientific Study of Sea Power	ABELL, SIR W. S.	1921–22
Seamless Steel Tubes	CHAMPNESS, G. T.	1936–37
Shafting Calculations	BLACKLOCK, W.	1955–6–7
Ship Repairs at Lisbon	DIXON, G.	1947–48
Ship Welding and the Influence of Residual Stresses	STOCKS, C. H., *and* THURSTON, J. W. G.	1946–47
Ships Electrical Installations and Their Surveys	DE JONG, W.	1970–71
Ships' Cargo Handling Gear	BECKWITH, L.	1962–63
Shipbuilding as a Means of Livelihood	LITHGOW, SIR JAMES, BT.	1935–36
Shipping as a Means of Livelihood ...	ESSENDON, THE RT. HON. LORD	1937–38
Simplified Short Circuit Calculations for Marine Alternating Current Networks	MORRIS, K., *and* KLEMM, K. H.	1970–71
Solid Drawn Steel Tubes and Air Receivers	PRINGLE, J.	1925–26
Stabilizing Turbine Rotors	HORNE, L. R.	1951–52
Stability and Seaworthiness of the Collier	WATT, W.	1925–26
Steam Pipes in Marine Practice ...	DAVIS, L. C.	1929–30
Steel Testing	HECK, W. D., *and* ROBERTSON, J. F.	1922–23
Steel Testing on the Occasional Attendance System	KOLBOW, H.	1924–25
Steel Tubes: Manufacture and Some Uses	CAMPBELL, R., *and* MCFARLANE, G.	1952–53
Steels Available for Marine Engineering and Shipbuilding with Special Reference to the Question of Corrosion	HATFIELD, W. H.	1922–23
Steering Gear	BUCHANAN, G.	1936–37
Steering Gear	LOCKHART, R. C.	1963–64
The Steering of Ships	PARKER, M. M.	1924–25
The Storage of Refrigerated Cargo on Board Vessels	GORDON, J. S.	1924–25
The Storage and Transfer of Liquid Fuel in Ships	DAVIS, L. C.	1921–22
Strain Gauge Technique	COGMAN, A. J.	1963–64
Strength of Ships	BALFOUR, W. M.	1933–34
The Structural Design of Fixed and Steerable Propeller Ducts	BARTON, R. F.	1973–74
Structural Problems in Ships with Large Hatch Openings	DE WILDE, IR. G.	1966–67
The Sub-division of Ships	JOHNSON, R. S.	1924–25
Survey and Repair of Old Trawlers ...	RENNIE, R.	1938–39
The Survey and Testing of Marine Electrical Equipment	MORRIS, W.	1961–62
The Survey and Testing of Welded Pressure Vessels	SUTHERST, H. L.	1938–39
The Survey of Crew Accommodation	SMITH, J. R. G., *and* BARROW, J. W.	1970–1
The Survey of Electrical Equipment ...	AUTERSON, G., CLAYTON, R. C., *and* HAFFNER, H.	1938–39
Survey of Machinery and Boilers During Construction in the Shops ...	BROWN, P. T.	1934–35
Survey of Mass Production	BROWN, P. T.	1946–47

Title	*Author*	*Session*
The Survey of Rudders	FLETCHER, H. L.	1926–27
The Survey of Safety Equipment ...	MACMILLAN, W.	1957–58
The Survey of Safety Equipment in Cargo Ships	SMART, G.	1970–71
The Survey of Wood Ships and Yachts	SHAW, G. M.	1926–27
Surveying in Portugal	GUTHRIE, J.	1951–52
Surveying OBO's and Large Bulk Carriers	MCINTOSH, G. S.	1974–75
Symposia:		
The Survey of Very Old Ships ...		1952–53
The Repair of Welded Ships ...		1952–53
Symposia:		
Novel Repairs and Unusual Features		1931–32
Novel Repairs and Unusual Features		1932–33
Novel Repairs and Unusual Features		1933–34
Symposia:		
Some Interesting and Unusual Features of Ship Design, Construction and Repair		1962–63
T		
Technical Records	BOYD, G. M.	1967–68
Technical Training and Information ...	STOOT, W. F., *and* SWIATECKI, T.	1969–70
Temporary Hull Repairs to the Tanker *Markay*	REID, A.	1946–47
Temporary Repairs	CAIRNS, R. D.	1923–24
Tensile Testing Machines	MILTON, J. H.	1949–50
Tensile Testing of Steel	LISTON, R., *and* HUSKINS, J. C.	1968–69
Three Island Vessels	MURRAY, J. M.	1933–34
Timbers: Their Characteristics, Preparation and Use in Ships, Yachts and Boats	BLOCKSIDGE, E. W.	1927–28
Tonnage	GRAY, R., *and* BECKWITH, L.	1958–59
Torsional Oscillations in Marine Engine Shafting	DOREY, S. F.	1929–30
Torsional Vibration from the Practical Viewpoint	ARCHER, S.	1951–52
Towage Surveys and Associated Work	VAN DUFFELEN, K.	1972–73
Transport of Petroleum by Sea ...	ZULVER, C.	1933–34
Trawling and Drifting	BARTLETT, C., *and* TOWNSHEND, S.	1920–21
Turbo-Electric Installation	HILLS, R. M.	1951–52
Types of Gas Turbine Plant Available for Marine Application	MCLEOD, N.	1947–48
U		
Use of Fork Lift Trucks	SMITH, W. S.	1962–63
V		
Vibration in Ships	CONSTANTINI, M.	1937–38
W		
Welding	PEMBERTON, H. N.	1934–35
With the Staff of Lloyd's Register in the 19th Century	SLADDEN, R. J.	1934–35
The Work of the Port of London Authority	RICHARDSON, J.	1973–74
Work of the Staff Department ...	VENNER, E. W.	1968–69
Y		
Yachts and Yachting in Sweden ..	ISAKON, A.	1923–24

AUTHOR INDEX

A

Author	Title	Session
Abell, Sir Westcott S.	The Scientific Study of Sea Power ...	1921–22
Adams, H. J.	Notes on Welding in Swedish Shipbuilding	1947–48
Adams, H. J.	Recent Development in Cargo Ship Design	1953–4–5
Akester, A. G.	The Effect of Beam Knees on the Transverse Strength of Vessels ...	1922–23
Akester, A. G.	Electric Welding as seen by the Outport Member	1932–33
Algate, C. F.	Classification Procedures	1969–70
Anderson, J.	Diesel Engine Design	1927–28
Archer, S.	Torsional Vibration from the Practical Viewpoint	1951–52
Atkinson, F. H.	*See* Harrison, R. P. Atkinson, F., *and* Dobson, R. J. C.	1973–74
Atkinson, F. H., *and* Sumner, S.	Some Further Notes on the Carriage of Liquefied Gases	1967–68
Auterson, G., Clayton, R. C., *and* Haffner, H.	The Survey of Electrical Equipment	1938–39

B

Author	Title	Session
Badger, W. T.	Electrical Fittings on Ships	1923–24
Balfour, A. K.	The Construction of Wood Yachts	1953–4–5
Balfour, W. M.	Strength of Ships	1933–34
Baker, G. S.	The National Experimental Tank ...	1927–28
Barrow, J. W.	*See* Smith, J. R. G., *and* Barrow, J. W.	1970–71
Bartlett, C.	Caulking	1931–32
Bartlett, C., *and* Townshend, S.	Trawling and Drifting	1920–21
Barton, R. F.	The Structural Design of Fixed and Steerable Propeller Ducts ...	1973–74
Bates, J. M.	*See* Simpson, T. A., Bates, J. M., *and* Beckwith, L. 1966 Load Line Convention: Its Applications and Interpretations	1969–70
Batten, B. K.	The Computer and Its Application to Lloyd's Register	1967–68
Batten, B. K.	An Introduction to Fatigue	1957–58
Beason, C.	*See* Buckle, A., *and* Beason, C. Hydrofoils	1965–66
Beckwith, L.	Ship's Cargo Handling Gear ...	1962–63
Beckwith, L.	*See* Gray, R., *and* Beckwith, L. Tonnage	1958–59
Beckwith, L.	*See* Simpson, T. A., Bates, J. M., *and* Beckwith, L. 1966 Load Line Convention: Its Implications and Interpretations	1969–70
Bedford, C. A.	Notes on the Survey of Water Tube Boilers	1946–47
Belch, A. R.	Lloyd's Register and the Shipbuilder	1973–74
Bennett, W.	Great Lakes Bulk Freighters ...	1928–29
Bennett, W.	Some Notes on the Development and Construction of the American Racing Yacht	1922–23
Bennett, W.	Some Notes on Wastage and Corrosion	1925–26
Bergmann, C. M.	Some Comments on Shafting and Sterntubes	1971–72
Beveridge, J. R.	Pumping Arrangements	1938–39
Beveridge, J. R.	*See* Bryden, S. T., Beveridge, J. R., *and* Watson, G. O. The 1948 International Convention on Safety of Life at Sea	1949–50
Blacker, L. V. Stewart-	Flying Over Mount Everest ...	1934–35
Blacklock, W.	Notes on Boiler, Air Receiver and Shafting Calculations, Part I: Boilers and Air Receivers ...	1954–55
Blacklock, W.	Shafting Calculations ...	1955–6–7
Blocksidge, E. W.	The Register Tonnage of Ships ...	1923–24
Blocksidge, E. W.	Timbers: Their Characteristics, Preparation and Use in Ships, Yachts and Boats	1927–28
Blocksidge, E. W.	*See* Townshend, S., *and others* Notes on Recent Developments in Large Passenger Ships (d) ...	1935–36
Bolding, J. D.	Fire Detection in Unattended Machinery Spaces	1970–71
Boyd, G. M.	Lessons to be Learned from the Appearance of Fractures ...	1951–52
Boyd, G. M.	Technical Records	1967–68
Boyd, G. M., *and* Drucquer, S. H.	Indexing and Analysis of Survey Reports	1948–49
Brand, S. D.	The Electrical Layout of Cargo Liners	1948–49
Brown, E. A.	Quality Control	1967–68
Brown, P. T.	The Fitting of Machinery on Board Ships	1931–32
Brown, P. T.	Some Notes on Auxiliary Machinery	1924–25
Brown, P. T.	Survey of Machinery and Boilers During Construction in the Shops	1934–35
Brown, P. T.	Survey of Mass Production	1946–47
Browne, A. J.	Data Processing at Lloyd's Register	1972–73
Bryden, S. T.	Docking: Stresses and Stability ...	1928–29
Bryden, S. T.	*See* Townshend, S., *and others* Notes on Recent Developments in Large Passenger Ships (c) ...	1935–36
Bryden, S. T., Beveridge, J. R., *and* Watson, G. O.	The 1948 International Convention on Safety of Life at Sea	1949–50
Buchanan, G.	Steering Gear	1936–37
Buchanan, J. G.	Hatchways	1936–37
Buckle, A. K.	Air Cushion Vehicles	1966–67
Buckle, A. K.	Anchoring and Mooring	1971–72
Buckle, A. K., *and* Beason, C.	Hydrofoils	1965–66
Bushell, T. W.	Modern Foundry Practice	1950–51
Butler, W.	The Electric Propulsion of Vessels by Synchronous Motors	1922–23

C

Author	Title	Session
Cairns, R. D.	Temporary Repairs	1923–24
Campbell, A.	Repairs to Machinery	1922–23
Campbell, F., *and* McFarlane, G.	Steel Tubes: Manufacture and Some Uses	1952–53
Cartwright, E. L.	Fruit and Chilled Cargoes from Australian Ports	1934–35
Champness, G. T.	Seamless Steel Tubes	1936–37
Christensen, C. F.	Notes on Whaling and Its Development	1938–39
Clarke, H.	Crank Shafts	1921–22
Clayton, H. R.	Pumping and Piping Arrangements	1959–60

Author	Title	Session
Clayton, R. C.	*See* Auterson, G., Clayton, R. C., *and* Haffner, H. The Survey of Electrical Equipment	1938–39
Clemmetsen, O. M.	Corrosion Control	1964–65
Clemmetsen, O. M.	Some Notes on Ship Plan Approval	1962–63
Cocks, F. C., *and* Pemberton, H. N.	Radiographic Inspection	1947–48
Cogman, A.	Electric Resistance Strain Gauges ...	1953–4–5
Cogman, A.	Strain Gauge Technique	1963–64
Coles, P. K.	Classed Refrigerated Installations ...	1971–72
Conn, J. F. C.	The Development of Hull Form ...	1936–37
Constantini, M.	Marking Off and Erecting in Trieste District	1922–23
Constantini, M.	Vibration in Ships	1937–38
Cowie, W.	Some Notes on New Processes and Alloys in Cast Metals	1928–29
Crighton, L. J.	Icebreakers, Their Design and Construction	1964–65
Cummins, C.	A Brief Guide to the Preparation and Presentation of Technical Papers	1973–74

D

Author	Title	Session
Daniel, R. D.	Public Relations	1972–73
Davies, J. B.	The Carriage of Liquefied Petroleum and Natural Gases	1961–62
Davies, J. B., Gray, D., Venner, E. W., *and* Warris, J. G. F.	Lloyd's Register Staff Association: The Past and the Future ...	1970–71
Davis, L. C.	Steam Pipes in Marine Practice ...	1929–30
Davis, L. C.	The Storage and Transfer of Liquid Fuel in Ships	1921–22
Dean, E. H.	Some Notes on the Construction and Details of the Welded Oil Tanker *Helicina*	1946–47
Derby, W. L. A.	The Relationship between Ship Classification and Marine Underwriting: With Comments on the Adjustment of Average Claims ...	1965–66
De Jong, W.	Ships Electrical Installations and Their Surveys	1970–71
De Wilde, Ir. G.	Structural Problems in Ships with Large Hatch Openings	1966–67
Dixon, G.	Ship Repairs at Lisbon	1947–48
Dobson, R. J. C.	*See* Harrison, R. P., Atkinson, F., *and* Dobson, R. J. C.	1973–74
Donald, K. M. B.	Marine Steam Turbines	1971–72
Dorey, S. F.	Combined Stresses	1926–27
Dorey, S. F.	Torsional Oscillations in Marine Engine Shafting	1929–30
Duly, C. J.	Problems of the Carriage of Perishable Cargoes by Sea	1931–32
Dunlop-Mackenzie, A.	The Oxford University Arctic Expedition, North East Land, 1935–36	1938–39

E

Author	Title	Session
Edgar, G. R.	The Basis of Hull Strength ...	1926–27
Edgar, G. R.	The Essentials in the Survey of Oil Tankers	1950–51
Essendon, The Rt. Hon. Lord	Shipping as a Means of Livelihood	1937–38
Ewing, A.	Boiler Surveys and Repairs	1928–29

F

Author	Title	Session
Findlay, A.	Cable Ships	1959–60
Fletcher, A.	Manufacture of Iron and Steel Forgings	1921–22
Fletcher, H. L.	The Survey of Rudders	1926–27
Forsyth, G. H., *and* Reed, C. W.	Behaviour of Steel at Elevated Temperatures	1932–33
Fraser-Smith, P. D., *and* Salisbury, P. R.	The Influence of Design on Longitudinal Bending Moments in Cargo Ships	1955–6–7
Freeman, S. B.	Marine Engines from the Superintendent's Point of View	1934–35

G

Author	Title	Session
Gemmell, D.	Refrigeration	1937–38
Gemmell, D.	Refrigerating Stores and Their Equipment	1930–31
Gibbeson, T. P.	Some Machinery Repairs	1949–50
Goodman, R. A.	Estimation of Ship Motions and Longitudinal Bending Moments ...	1966–67
Gordon, J. S.	The Storage of Refrigerated Cargo on Board Vessels	1924–25
Gray, D.	Behaviour of Control Equipment in a Steam Turbine Tanker	1969–70
Gray, D.	*See* Davies, J. B., Gray, D., Venner, E. W., *and* Warris, J. G. F.	1970–71
Gray, R., *and* Beckwith, L.	Tonnage	1958–59
Grove, J. M.	Notes on the Manufacture and Testing of Shipbuilding Materials in the United States	1948–49
Guthrie, J.	Bizarre Craft of Portugal	1947–48
Guthrie, J.	Freak Ships of the XIXth Century	1966–67
Guthrie, J.	The Machinery of the *Great Eastern*	1961–62
Guthrie, J.	Marine Engine Repairs	1959–60
Guthrie, J.	Surveying in Portugal	1951–52

H

Author	Title	Session
Haffner, H.	*See* Auterson, G., Clayton, R. C., *and* Haffner, H. The Survey of Electrical Equipment	1938–39
Hancock, J.	Application of On-line Computers in Ships	1970–71
Hague, D.	Some Notes on a Large Tanker Machinery Installation	1972–73
Handley-Page, F.	The Problems of Lift and Stability in Aeroplane Design	1930–31
Harbottle, J.	The Doxford Opposed Piston Airless Engine	1928–29
Harrison, R. P.	Aluminium in Shipbuilding ...	1955–6–7
Harrison, R. P.	Lloyd's Register of Shipping's Relations with IMCO and IACS ...	1973–74
Harrison, R. P., Atkinson, F. H., *and* Dobson, R. J. C.	The International Conference on Marine Pollution, 1973 and resulting International Convention ...	1973–74
Hatfield, W. H.	Steels Available for Marine Engineering and Shipbuilding with Special Reference to the Question of Corrosion	1922–23
Heck, W. D.	Chain Cables and Their Testing ...	1938–39
Heck, W. D., *and* Robertson, J. F.	Steel Testing	1922–23

Author	Title	Session
HEDGER, A. J. W.	Reinforced Plastics	1957–58
HILDREW, B.	Alignment in Marine Engines, Part I: Turbines to Pinions ...	1952–53
HILDREW, B.	Alignment of Marine Engines, Part II: Shafting	1955–6–7
HILDREW, B.	Nuclear Energy: Its Source and Its Application to Marine Engineering	1960–61
HILL, L. J.	General Notes on the Inspection of Aircraft	1931–32
HILLS, R. M.	Turbo-Electric Installation	1951–52
HINSON, A. R.	First Steps in Control Engineering Made Easy	1968–69
HINSON, A. R.	Notes on Vibration Problems ...	1960–61
HOBBS, W. L.	*See* MCINNES, A., *and* HOBBS, W. L. Glass Reinforced Plastic Boat Building, Parts III and IV	1963–64
HOBBS, W. L.	Resin Bonded Wood Laminates in Marine Construction	1959–60
HOOK, R. J.	Some Notes on Free Piston Gas Turbine Machinery for Marine Applications	1960–61
HOOK, R. J.	Index to the Transactions 1920–1962	1962–63
HOOK, R. J.	Index to the Transactions 1920–1970	1969–70
HOOK, R. J.	Index to the Transactions 1920–1975	1974–75
HORNE, L. R.	Electric Propulsion of Ships ...	1931–32
HORNE, L. R.	Stabilizing Turbine Rotors	1951–52
HOW, A. P.	Forty Years Reminiscences of Yachts and Yachting	1923–24
HUBBARD, G. S.	Indicating and Recording Instruments	1968–69
HUNTER, C.	Internal Combustion Engines ...	1920–21
HUSKINS, J. C.	*See* LISTON, R., *and* HUSKINS, J. C. Tensile Testing of Steel	1968–69
I		
INGLEBY, J. H.	Glass—A short Account of the Development of Its Manufacture, and Some of Its Properties ...	1965–66
ISAKSON, A.	Yachts and Yachting in Sweden ...	1923–24
IVES, B. J.	Classification and Seaworthiness ...	1924–25
J		
JACKSON, A. W.	Remarks on Shipbuilding Practice	1937–38
JAFFREY, J. A.	Alternating or Direct Current on Shipboard	1951–52
JANZEN, S., *and* NILLSON, O.	Hull Damage in Large Ships ...	1972–73
JOHNSON, R. S.	The Sub-division of Ships	1924–25
JONG, DE W., *see* DE JONG, W.		
JORDAN, C. H.	Some Historical Records and Reminiscences Relating to the British Navy and Mercantile Shipping ...	1924–25
K		
KENNEDY, A. M.	Lessons from Welded Ships Structural Failures and Repairs ...	1950–51
KERTSCHER, P.	Inspection of Materials in the Prague District	1931–32
KILGOUR, V. L.	Notes on Edible Oil Quantity Surveys	1958–59
KLEMM, K. H.	*See* MORRIS, K., *and* KLEMM, K. H.	1970–71
KNOWLES, E. L.	Some Notes on Engine Reports ...	1958–59
KNOWLES, W. C. G.	The Future of the Society	1968–69
KOLBOW, H.	Steel Testing on the Occasional Attendance System ...	1924–25

Author	Title	Session
L		
LAMPLOUGH, T. A.	Some Aspects of Propeller Excited Vibration	1961–62
LANGLANDS, R.	Some Notes on Plating and Riveting	1920–21
LARSEN, K.	Control Dynamics	1968–69
LAST, F. B.	Rudders and Sternframes	1957–58
LEA, F. C.	The Behaviour of Metals under Repeated Stresses	1926–27
LEE ANNEAR, R.	Some Notes on the Survey of Diesel Engines	1926–27
LEE ANNEAR, R.	*See* TOWNSHEND, S., *and others* Notes on Recent Developments in Large Passenger Ships (b) ...	1935–36
LEWIS, W. E.	Engineering Materials Stressed at Superheat Temperatures	1929–30
LISMER, R. E.	Corrosion and Corrosion Prevention in Metals	1955–6–7
LISMER, R. E.	Developments in Carbon Steels ...	1963–64
LISTON, R.	Recent Developments in Steel Making Practice	1962–63
LISTON, R.	Tensile Testing of Steel	1968–69
LITHGOW, SIR JAMES, BT.	Shipbuilding as a means of Livelihood	1935–36
LOCKHART, R. C.	Steering Gear	1963–64
LOWSON, J. A.	Composite Vessels	1930–31
LOWSON, J. A.	Some Notes on the Construction of Wood Ships and Yachts	1927–28
M		
MACBEAN, L. D.	General Notes on Great Lakes Ships	1953–4–5
MACDONALD, J.	Deterioration and Repairs of Steel Ships	1921–22
MACDONALD, J.	The Practical Construction of Oil Tankers	1930–31
MACKECHNIE, H.	Hull Surveys and Where to Look for Defects	1957–58
MACKENZIE, A. DUNLOP-	*See* DUNLOP-MACKENZIE, A. The Oxford University Arctic Expedition, North East Land, 1935–36	1938–39
MACLEOD, M.	Notes on Various Types of Dredgers and Barges	1935–36
MACMILLAN, W.	The Survey of Safety Equipment ...	1957–58
MCAFEE, J.	Boiler Explosions	1950–51
MCCALLUM, J.	The Design and Classification of a Nuclear Powered Ship	1960–61
MCCRIRICK, H.	Development of the Four Stroke Cycle Marine Diesel Engine ...	1927–28
MCCRIRICK, H.	Propellers	1934–35
MCFARLANE, G.	*See* CAMPBELL, F., *and* MCFARLANE, G. Steel Tubes: Manufacture and Some Uses	1952–53
MCINNES, A.	Glass Reinforced Plastic Boat Building. Parts I and II	1962–63
MCINNES, A.	Glass Reinforced Plastic Boat Building. Parts V and VI	1964–65
MCINNES, A., *and* HOBBS, W. L.	Glass Reinforced Plastic Boat Building. Parts III and IV	1963–64
MCKINLAY, F. S. J.	Longitudinal Stresses in Modern Canadian Great Lakes Bulk Freighters	1963–64
MCINTOSH, G. S.	Surveying OBO's and Large Bulk Carriers	1974–75
MCLEOD, N.	Types of Gas Turbine Plant Available for Marine Application ...	1947–48

Author	Title	Session
Manley, C. V.	Some Early Technical Records of Ship Department	1958–59
Marchant, A. W.	Recent Developments of Wireless Telegraphy	1921–22
Mathewson, J. I., *and* A. C. Viner	Buckling as a Mode of Failure in Ship Structures	1970–71
Miles, G. H. M.	Notes on the Operation and Maintenance of Commercial Aircraft	1932–33
Millar, W. C.	Merchant Shipbuilding in Australia	1949–50
Milton, J. H.	Interesting Investigations	1961–62
Milton, J. H.	Tensile Testing Machines	1949–50
Milton, J. T.	The Measurements of Exceedingly Large and Extremely Small Quantities	1920–21
Milton, J. T.	Remarks on Castings	1923–24
Morris, K., *and* Klemm, K. H.	Simplified Short Circuit Calculations for Marine Alternating Current Networks	1970–71
Morris, W.	The Survey and Testing of Marine Electrical Equipment	1961–62
Morrison, R.	Electro-Slag Welding	1963–64
Munro, R. F	13 % Chromium Steel Water Turbine Castings in Switzerland and Their Repair by Welding	1964–65
Murray, J. M.	Longitudinal Stresses in Ships ...	1951–52
Murray, J. M.	Marine Corrosion	1952–53
Murray, J. M.	The New Approach to Longitudinal Strength	1961–62
Murray, J. M.	Three Islands Vessels	1933–34
Musters, R.	*See* Tyler, J., *and* Musters, R. ...	1972–73

N

Author	Title	Session
Navaz, M. Z.	Refrigerated Liquefied Gas Carriers (Heat Transfer—Cargo Conditioning and Commissioning)	1968–69
Naysmith, J.	The Effect of Metallurgical Variables on the Brittle Fracture of Mild and Medium Carbon Steels ...	1965–66
Nell, T.	Some Remarks Arising from Damage Surveys	1950–51
Nilsson, O.	Some Notes on the Hull Survey of New Construction in Sweden ...	1969–70
Nilsson, O.	*See* Janzen, S., *and* Nilsson, O. ...	1972–73

O

Author	Title	Session
Ormiston, J. S.	Notes on Strength of Ships	1923–24

P

Author	Title	Session
Parker, M. M.	The Steering of Ships	1924–25
Patchin, G.	The Heat Treatment of Steel ...	1923–24
Pedder, F. W.	The Preparation and Delivery of Unusual Types of Vessels for Overseas Service	1929–30
Pemberton, H. N.	Welding	1934–35
Pemberton, H. N.	*See* Cocks, F. C., *and* Pemberton, H. N. Radiographic Inspection	1947–48
Phillip, L. D.	Some Notes on Writing Damage Reports	1974–75
Pickworth, A.	Corrosion	1922–23
Porter, C. S.	The Manufacture and Heat Treatment of Steel Forgings	1934–35
Priest, E. W.	The Inspection of Pre-stressed Concrete Beams	1966–67
Pringle, J.	Solid Drawn Steel Tubes and Air Receivers	1925–26

R

Author	Title	Session
Rawson, K. J.	Some Developments in the Ministry of Defence	1970–71
Reed, C. W.	*See* Forsyth, G. H., *and* Reed, C. W. Behaviour of Steel at Elevated Temperatures	1932–33
Reed, C. W.	*See* Townshend, S., *and others* Notes on Recent Developments in Large Passenger Ships (f) ...	1935–36
Reid, A.	Temporary Hull Repairs to the Tanker *Markay*	1946–47
Rennie, R.	Survey and Repair of Old Trawlers	1938–39
Richardson, J.	The Work of the Port of London Authority	1973–74
Ripley, L.	Some Observations on Steel Founding	1924–25
Roberts, W. H.	Corrugated Furnaces for Marine Boilers	1927–28
Robertson, M.	Forging Practice	1920–21
Ronald, W.	Ocean Type Vessels—Some Notes on Bottom Stiffening and Welding Procedure	1949–50
Rosen, Jac. V.	The Carriage of Timber in the Baltic	1926–27
Rowell, E. W.	The Printing House	1972–73

S

Author	Title	Session
Salisbury, P. R.	*See* Fraser-Smith, P. D., *and* Salisbury, P. R. The Influence of Design on Longitudinal Bending Moments in Cargo Ships	1955–6–7
Sarginson, J. R.	Some Recent Developments in Swedish Shipbuilding	1958–59
Savours, J. L.	Some Notes on Non-Marine Work	1969–70
Scheelings, W. B.	Joining Ships Afloat	1968–69
Schiff, A.	Lloyd's Register and the Marine Engine Builder	1974–75
Sdorowok, V. F. J.	Compressors	1934–35
Sedgwick, S.	Salvage Association Damage Surveys	1965–66
Shaw, G. M.	The Survey of Wood Ships and Yachts	1926–27
Shaw, T.	Notes on Special Surveys	1935–36
Shepheard, R. B.	Coasting Vessels	1929–30
Shepheard, R. B.	Electric Welding in German Shipbuilding	1937–38
Simpson, T. A., Bates, J. M., *and* Beckwith, L.	1966 Load Line Convention: Its Implications and Interpretations	1969–70
Sladden, R. J.	Classification Procedure	1949–50
Sladden, R. J.	Notes and Anecdotes on the Society's Staff During the Victorian Era ...	1948–49
Sladden, R. J.	With the Staff of Lloyd's Register in the 19th Century	1934–35
Slater, I. G.	Russian Higher Technological Education and Industry	1959–60
Slater, I. G.	"Brazil"	1960–61
Smart, G.	The Survey of Safety Equipment in Cargo Ships	1970–71

Author	Title	Session
Smith, E. C.	Some Early Marine Engineering Experiences and Practice	1935–36
Smith, F. G. B.	Notes on Surveying Duties in Foreign Ports	1933–34
Smith, J. R. G., *and* Barrow, J. W.	The Survey of Crew Accommodation	1970–71
Smith, P. D. Fraser-	*See* Fraser-Smith, P. D.	
Smith, W. S.	Use of Fork Lift Trucks	1962–63
Southwell, H. P.	Notes on Foreign Service	1948–49
Stocks, C. H., *and* Thurston, J. W. G.	Ship Welding and the Influence of Residual Stresses	1946–47
Stoot, W. F., *and* Swiatecki, T.	Technical Training and Information	1969–70
Sturge, A. L.	Notes on Insurance	1932–33
Sumner, S.	*See* Atkinson, *and* Sumner, S.	
	Some Further Notes on the Carriage of Liquefied Gases	1967–68
Sutherst, H. L.	The Survey and Testing of Welded Pressure Vessels	1938–39
Swiatecki, T.	*See* Stoot, W. F., *and* Swiatecki, T.	
	Technical Training and Information	1969–70
	T	
Teasdale, L.	Gearing	1959–60
Thomson, H.	Recent Developments in Oil Ship Construction	1920–21
Thomson, H. J.	Ice Navigation and Damage in the Baltic	1924–25
Thomson, W.	Comparative Stresses in Oil and Cargo Ships	1921–22
Thurston, J. W. G.	*See* Stocks, C. H., *and* Thurston, J. W. G.	
	Ship Welding and the Influence of Residual Stresses	1946–47
Townend, S.	Some Notes on Refrigeration	1925–26
Townshend, S., *and others*	Notes on Recent Developments in Large Passenger Ships	1935–36
	(a) Structural, by S. Townshend	
	(b) Propelling Machinery, by R. Lee Annear	
	(c) Sub-division, by S. T. Bryden	
	(d) Life-saving Appliances, by E. W. Blocksidge	
	(e) Electrical Equipment, by G. O. Watson	
	(f) Fire Protection, by C. W. Reed	
Turner, D.	Report 8—A few General Notes	1953–4–5
Tyler, J., *and* Musters, R.	Some Practical Aspects of Moulding G.R.P. Yachts and Small Craft	1974–75

Author	Title	Session
	U	
Urwin, A.	The Joint Action of Fatigue and Corrosion	1929–30
	V	
Van Duffelen, K.	Towage Surveys and Associated Work	1972–73
Venner, E. W.	Work of the Staff Department	1968–69
Venner, E. W.	*See* Davies, J. B., Gray, D., Venner, E.W., *and* Warris, J. G. F.	1970–71
	W	
Walburn, D. R.	Lloyd's Register Activities in Post-War Germany	1957–58
Wallis, B. N.	Some Technical Aspects of the Commercial Airship	1925–26
Walsh, J. V.	Some Considerations Favouring Metal in the Construction of Small Hulls	1957–58
Warris, J. G. F.	*See* Davies, J. B., Gray, D., Venner, E.W., *and* Warris, J. G. F.	1970–71
Watson, G. O.	Manufacture, Survey and Testing of Electrical Equipment	1936–37
Watson, G. O.	*See* Bryden, S. T., Beveridge, J. R., *and* Watson, G. O.	
	The 1948 International Convention on Safety of Life at Sea	1949–50
Watson, G. O.	*See* Townshend, S., *and others*	
	Notes on Recent Developments in Large Passenger Ships (e)	1935–36
Watt, A	Notes on Tail Shafts	1948–49
Watt, W.	The Freeboard, Stability and Seaworthiness of Shelter Deck Steamers	1920–21
Watt, W.	The History of British Freeboard Regulations	1923–24
Watt, W.	The History of British Freeboard Regulations, 1922–1930	1930–31
Watt, W.	Stability and Seaworthiness of the Collier	1925–26
Webster, G.	Floating Docks	1920–21
Wilde De, Ir. G.	*See* De Wilde, Ir. G.	
	Structural Problems in Ships with Large Hatch Openings	1966–67
Witt, F. C. M.	Recent Developments in Marine Engineering in Germany	1930–31
Woodeson, E. W.	Pulverised Fuel and its Particular Application to Marine Boilers	1928–29
Wordsworth, A. C.	Model Structural Testing Techniques	1970–71
Wormald, J.	Some Notes on Deep Tanks for Edible Oil and Similar Cargoes	1949–50
	Z	
Zulver, C.	Transport of Petroleum by Sea	1933–34

CHRONOLOGICAL INDEX

SESSION 1920–21

The Measurements of Exceedingly Large and Extremely Small Quantities ... J. T. MILTON
The Freeboard, Stability and Seaworthiness of Shelter Deck Steamers ... W. WATT
Forging Practice ... ... M. ROBERTSON
Recent Developments in Oil Ship Construction ... ... H. THOMSON
Some Notes on Plating and Riveting ... R. LANGLANDS
Trawling and Drifting ... C. BARTLETT *and* S. TOWNSHEND
Internal Combustion Engines ... ... C. HUNTER
Floating Docks ... ... G. WEBSTER

SESSION 1921–22

Deterioration and Repairs of Steel Ships J. MACDONALD
Recent Development of Wireless Telegraphy ... ... A. W. MARCHANT
Manufacture of Iron and Steel Forgings A. FLETCHER
The Scientific Study of Sea Power SIR WESTCOTT S. ABELL
The Storage and Transfer of Liquid Fuel in Ships ... ... L. C. DAVIS
Crank Shafts ... ... H. CLARKE
Comparative Stresses in Oil and Cargo Ships ... ... W. THOMSON

SESSION 1922–23

Repairs to Machinery ... ... A. CAMPBELL
Steels Available for Marine Engineering and Shipbuilding with Special Reference to the Question of Corrosion ... W. H. HATFIELD
Some Notes on the Development and Construction of the American Racing Yacht ... ... W. BENNETT
The Effect of Beam Knees on the Transverse Strength of Vessels ... ... A. G. AKESTER
The Electric Propulsion of Vessels by Synchronous Motors ... ... W. BUTLER
Marking Off and Erecting in Trieste District ... ... M. CONSTANTINI
Steel Testing ... W. D. HECK *and* J. F. ROBERTSON
Corrosion ... ... A. PICKWORTH

SESSION 1923–24

Remarks on Castings ... ... J. T. MILTON
The History of British Freeboard Regulations ... ... W. WATT
The Heat Treatment of Steel ... ... G. PATCHIN
Yachts and Yachting in Sweden ... A. ISAKSON
Forty Years Reminiscences of Yachts and Yachting ... ... A. P. HOW
Temporary Repairs ... ... R. D. CAIRNS
Notes on Strength of Ships ... ... J. S. ORMISTON
Electrical Fittings on Ships ... ... W. T. BADGER
The Register Tonnage of Ships ... ... E. W. BLOCKSIDGE

SESSION 1924–25

The Storage of Refrigerated Cargo on Board Vessels ... ... J. S. GORDON
The Steering of Ships ... ... M. M. PARKER
Classification and Seaworthiness ... B. J. IVES
Ice Navigation and Damage in the Baltic H. J. THOMSON
Some Observations on Steel Founding ... L. RIPLEY
The Sub-division of Ships ... ... R. S. JOHNSON
Steel Testing on the Occasional Attendance System ... ... H. KOLBOW
Some Notes on Auxiliary Machinery ... P. T. BROWN
Some Historical Records and Reminiscences relating to the British Navy and Mercantile Shipping ... ... C. H. JORDAN

SESSION 1925–26

Stability and Seaworthiness of the Collier W. WATT
Solid Drawn Steel Tubes and Air Receivers ... ... J. PRINGLE
Some Notes on Refrigeration ... ... S. TOWNEND
Some Notes on Wastage and Corrosion W. BENNETT
Some Technical Aspects of the Commercial Airship ... ... B. N. WALLIS

SESSION 1926–27

The Survey of Wood Ships and Yachts G. M. SHAW
Combined Stresses ... ... S. F. DOREY
The Survey of Rudders ... ... H. L. FLETCHER
The Basis of Hull Strength ... ... G. R. EDGAR
The Carriage of Timber in the Baltic ... JAC. V. ROSEN
The Behaviour of Metals under Repeated Stresses ... ... F. C. LEA
Some Notes on the Survey of Diesel Engines ... ... R. LEE ANNEAR

SESSION 1927–28

Some Notes on the Construction of Wood Ships and Yachts ... ... J. A. LOWSON
Corrugated Furnaces for Marine Boilers W. H. ROBERTS
Timbers: Their Characteristics, Preparation and use in Ships, Yachts and Boats E. W. BLOCKSIDGE
Diesel Engine Design ... ... J. ANDERSON
The National Experimental Tank ... G. S. BAKER
Development of the Four Stroke Cycle Marine Diesel Engine ... ... H. MCCRIRICK

SESSION 1928–29

Boiler Surveys and Repairs ... ... A. EWING
Docking: Stresses and Stability ... ... S. T. BRYDEN
Some Notes on New Processes and Alloys in Cast Metals ... ... W. COWIE
Great Lakes Bulk Freighters ... ... W. BENNETT
Pulverised Fuel and its Particular Application to Marine Boilers ... ... E. W. WOODESON
The Doxford Opposed Piston Airless Engine ... ... J. HARBOTTLE

SESSION 1929–30

Engineering Materials Stressed at Superheat Temperatures ... ... W. E. Lewis

Torsional Oscillations in Marine Engine Shafting ... ... S. F. Dorey

The Joint Action of Fatigue and Corrosion ... ... A. Urwin

Steam Pipes in Marine Practice ... ... L. C. Davis

The Preparation and Delivery of Unusual Types of Vessels for Overseas Service F. W. Pedder

Coasting Vessels ... ... R. B. Shepheard

SESSION 1930–31

The Problem of Lift and Stability in Aeroplane Design ... ... F. Handley-Page

The Practical Construction of Oil Tankers J. Macdonald

Recent Developments in Marine Engineering in Germany ... ... F. C. M. Witt

The History of British Freeboard Regulations, 1922–1930 ... ... W. Watt

Composite Vessels ... ... J. A. Lowson

Refrigerating Stores and their Equipment D. Gemmell

SESSION 1931–32

Problems of the Carriage of Perishable Cargoes by Sea ... ... C. J. Duly

Electric Propulsion of Ships ... ... L. R. Horne

General Notes on the Inspection of Aircraft ... ... L. J. Hill

The Fitting of Machinery on Board Ships P. T. Brown

Inspection of Materials in the Prague District ... ... P. Kertscher

Caulking ... ... C. Bartlett

Novel Repairs and Unusual Features ... A Symposium

SESSION 1932–33

Notes on Insurance ... ... A. L. Sturge

Electric Welding as seen by the Outport Member ... ... A. G. Akester

Behaviour of Steel at Elevated Temperatures ... ... G. H. Forsyth *and* C. W. Reed

Notes on the Operation and Maintenance of Commercial Aircraft ... ... G. H. M. Miles

Novel Repairs and Unusual Features ... A Symposium

SESSION 1933–34

Strength of Ships ... ... W. M. Balfour

Notes on Surveying Duties in Foreign Ports ... ... F. G. B. Smith

Three Island Vessels ... ... J. M. Murray

Transport of Petroleum by Sea ... ... C. Zulver

Novel Repairs and Unusual Features ... A Symposium

SESSION 1934–35

Flying over Mount Everest ... L. V. Stewart Blacker

Compressors ... ... V. F. J. Sdorowok

With the Staff of Lloyd's Register in the 19th Century ... ... R. J. Sladden

Welding ... ... H. N. Pemberton

Marine Engines from the Superintendent's Point of View ... ... S. B. Freeman

Survey of Machinery and Boilers during Construction in the Shops ... P. T. Brown

The Manufacture and Heat Treatment of Steel Forgings ... ... C. S. Porter

Propellers ... ... H. McCririck

Fruit and Chilled Cargoes from Australian Ports ... ... E. L. Cartwright

SESSION 1935–36

Shipbuilding as a means of Livelihood Sir James Lithgow, Bt.

Some Early Marine Engineering Experiences and Practice ... ... E. C. Smith

Notes on Special Surveys ... T. Shaw

Notes on various types of Dredgers and Barges ... ... M. Macleod

Notes on Recent Developments in Large Passenger Ships:—

(a) Structural ... ... S. Townshend

(b) Propelling Machinery ... R. Lee Annear

(c) Sub-division ... ... S. T. Bryden

(d) Life-Saving Appliances ... E. W. Blocksidge

(e) Electrical Equipment ... G. O. Watson

(f) Fire Protection ... ... C. W. Reed

SESSION 1936–37

The Development of Hull Form ... J. F. C Conn

Steering Gear ... ... G. Buchanan

Hatchways ... ... J. G. Buchanan

Seamless Steel Tubes ... ... G. T. Champness

Manufacture, Survey and Testing of Electrical Equipment ... ... G. O. Watson

SESSION 1937–38

Remarks on Shipbuilding Practice ... A. W. Jackson

Shipping as a Means of Livelihood The Rt. Hon. Lord Essendon

Electric Welding in German Shipbuilding R. B. Shepheard

Vibration in Ships ... ... M. Constantini

Refrigeration ... ... D. Gemmell

SESSION 1938–39

Notes on Whaling and its Development C. F. Christensen

Survey and Repair of Old Trawlers ... R. Rennie

The Survey of Electrical Equipment G. Auterson, R. C. Clayton *and* H. Haffner

The Oxford University Arctic Expedition, North East Land, 1935–1936 ... A. Dunlop-Mackenzie

The Survey and Testing of Welded Pressure Vessels ... ... H. L. Sutherst

Pumping Arrangements ... ... J. R. Beveridge

Chain Cables and Their Testing ... W. D. Heck

SESSIONS 1939–40 TO 1945–46

Association Suspended from Session

SESSION 1946–47

Survey of Mass Production ... ... P. T. Brown

Temporary Hull Repairs to the Tanker *Markay* ... ... A. Reid

Notes on the Survey of Water Tube Boilers ... ... C. A. Bedford

Ship Welding and the Influence of Residual Stresses ... ... C. H. Stocks *and* J. W. G. Thurston

Some Notes on the Construction and Details of the Welded Oil Tanker *Helicina* ... ... E. H. Dean

SESSION 1947–48

Classification Procedure ... ... R. J. Sladden

Ship Repairs at Lisbon ... ... G. Dixon

Bizarre Craft of Portgual ... ... J. Guthrie

Radiographic Inspection ... ... F. C. Cocks *and* H. N. Pemberton

Types of Gas Turbine Plant Available for Marine Application ... ... N. McLeod

Notes on Welding in Swedish Shipbuilding ... ... H. J. Adams

SESSION 1948–49

Notes and Anecdotes on the Society's Staff During the Victorian Era ... R. J. Sladden

Notes on Tail Shafts ... ... A. Watt

The Electrical Layout of Cargo Liners ... S. D. Brand

Notes on Foreign Service ... ... H. P. Southwell

Notes on the Manufacture and Testing of Shipbuilding Materials in the United States ... ... J. M. Grove

Indexing and Analysis of Survey Reports G. M. Boyd *and* S. H. Drucquer

SESSION 1949–50

Tensile Testing Machines ... ... J. H. Milton

Some Notes on Deep Tanks for Edible Oil and Similar Cargoes ... ... J. Wormald

Merchant Shipbuilding in Australia ... W. C. Millar

Some Machinery Repairs ... ... T. P. Gibbeson

Ocean Type Vessels—Some Notes on Bottom Stiffening and Welding Procedure ... ... W. Ronald

The 1948 International Convention on Safety of Life at Sea ... ... S. T. Bryden, J. R. Beveridge *and* G. O. Watson

SESSION 1950–51

Some Remarks Arising from Damage Surveys ... ... T. Nell

Boiler Explosions ... ... J. McAfee

Lessons from Welded Ship Structural Failures and Repairs ... ... A. M. Kennedy

Modern Foundry Practice ... ... T. W. Bushell

The Essentials in the Survey of Oil Tankers ... ... G. R. Edgar

SESSION 1951–52

Longitudinal Stresses in Ships ... ... J. M. Murray

Torsional Vibration from the Practical Viewpoint ... ... S. Archer

Surveying in Portugal ... ... J. Guthrie

Alternating or Direct Current on Shipboard ... ... J. A. Jaffrey

Lessons to be learned from the Appearance of Fractures ... ... G. M. Boyd

Turbo-Electric Installation ... ... R. M. Hills

Stabilizing Turbine Rotors ... ... L. R. Horne

SESSION 1952–53

Marine Corrosion ... ... J. M. Murray

Steel Tubes: Manufacture and Some Uses ... ... F. Campbell *and* G. McFarlane

Alignment in Marine Engines, Part I: Turbines to Pinions ... ... B. Hildrew

Symposia: The Survey of Very Old Ships

The Repair of Welded Ships

SESSIONS 1953–54 AND 1954–55

Electric Resistance Strain Gauges ... A. Cogman

Notes on Boiler Air Receiver and Shafting Calculations, Part I: Boilers and Air Receivers ... ... W. Blacklock

The Construction of Wood Yachts ... A. K. Balfour

General Notes on Great Lakes Ships ... L. D. MacBean

Report 8—A Few General Notes ... D. Turner

Recent Development in Cargo Ship Design ... ... H. J. Adams

SESSIONS 1955–56 AND 1956–57

The Influence of Design on Longitudinal Bending Moments in Cargo Ships ... P. D. Fraser-Smith *and* P. R. Salisbury

Shafting Calculations ... ... W. Blacklock

Alignment of Marine Engines, Part II: Shafting ... ... B. Hildrew

Aluminium in Shipbuilding ... ... R. P. Harrison

Corrosion and Corrosion Prevention in Metals ... ... R. E. Lismer

SESSION 1957–58

Rudders and Sternframes ... ... F. B. Last

The Survey of Safety Equipment ... W. Macmillan

Hull Surveys and Where to Look for Defects ... ... H. Mackechnie

An Introduction to Fatigue ... ... B. K. Batten

Reinforced Plastics ... ... A. J. W. Hedger

Lloyd's Register's Activities in Post-War Germany ... ... D. R. Walburn

Some Considerations Favouring Metal in the Construction of Small Hulls ... J. V. Walsh

SESSION 1958–59

Some Recent Developments in Swedish Shipbuilding ... ... J. R. SARGINSON
Tonnage ... ... R. GRAY *and* L. BECKWITH
Somes Notes on Engine Reports ... E. L. KNOWLES
Some Early Technical Records of Ship Department ... ... C. V. MANLEY
Notes on Edible Oils Quantity Surveys V. L. KILGOUR

SESSION 1959–60

Marine Engine Repairs ... ... J. GUTHRIE
Cable Ships ... ... A. FINDLAY
Pumping and Piping Arrangements ... H. R. CLAYTON
Russian Higher Technological Education and Industry ... ... I. G. SLATER
Gearing ... ... L. TEASDALE
Resin Bonded Wood Laminates in Marine Construction ... ... W. L. HOBBS

SESSION 1960–61

Some Notes on Free Piston Gas Turbine Machinery for Marine Applications ... R. J. HOOK
Notes on Vibration Problems ... ... A. R. HINSON
Nuclear Energy—Its source and Its Application to Marine Engineering ... B. HILDREW
"Brazil" ... ... I. G. SLATER
The Design and Classification of a Nuclear Powered Ship ... J. MCCALLUM

SESSION 1961–62

Some Aspects of Propeller Excited Vibrations ... ... T. A. LAMPLOUGH
The Machinery of the *Great Eastern* ... J. GUTHRIE
The Survey and Testing of Marine Electrical Equipment ... W. MORRIS
The New Approach to Longitudinal Strength ... ... J. M. MURRAY
Interesting Investigations ... ... J. H. MILTON
The Carriage of Liquefied Petroleum and Natural Gases ... ... J. B. DAVIES

SESSION 1962–63

Some Interesting and Unusual Features of Ship Design, Construction and Repair ... ... A Symposium
Glass Reinforced Plastic Boat Building: Parts I and II ... ... A. MCINNES
Some Notes on Ship Plan Approval ... O. M. CLEMMETSEN
Ships' Cargo Handling Gear ... ... L. BECKWITH
Recent Developments in Steel Making Practice ... ... R. LISTON
Use of Fork Lift Trucks ... ... W. S. SMITH
Index to the Transactions 1920–1962 ... R. J. HOOK

SESSION 1963–64

Electro-Slag Welding ... ... R. MORRISON
Longitudinal Stresses in Modern Canadian Great Lakes Bulk Freighters ... F. S. J. MCKINLEY
Strain Gauge Technique ... ... A. J. COGMAN
Glass Reinforced Plastic Boat Building: Parts III and IV ... A. MCINNES *and* W. L. HOBBS
Developments in Carbon Steels ... ... R. E. LISMER
Steering Gear ... ... R. C. LOCKHART

SESSION 1964–65

13% Chromium Steel Water Turbine Castings in Switzerland and their Repair by Welding ... ... R. F. MUNRO
Icebreakers, their Design and Construction ... ... L. J. CRIGHTON
Corrosion Control ... ... O. M. CLEMMETSEN
Glass Reinforced Plastic Boatbuilding: Parts V and VI ... ... A. MCINNES

SESSION 1965–66

Hydrofoils ... ... A. BUCKLE *and* C. BEASON
Salvage Association Damage Surveys ... S. SEDGWICK
Glass—A short account of the Development of its Manufacture, and some of its Properties ... ... J. H. INGLEBY
The Relationship Between Ship Classification and Marine Underwriting: With Comments on the Adjustment of Average Claims ... ... W. L. A. DERBY
The Effect of Metallurgical Variables on the Brittle Fracture of Mild and Medium Carbon Steels ... ... J. NAYSMITH

SESSION 1966–67

Freak Ships of the XIXth Century ... J. GUTHRIE
Estimation of Ship Motions and Longitudinal Bending Moments ... ... R. A. GOODMAN
The Inspection of Pre-stressed Concrete Beams ... ... E. W. PRIEST
Air Cushion Vehicles ... ... A. K. BUCKLE
Structural Problems in Ships with Large Hatch Openings ... ... IR. G. DE WILDE

SESSION 1967–68

The Computer and its Application to Lloyd's Register ... ... B. K. BATTEN
Technical Records ... ... G. M. BOYD
Some Further Notes on the Carriage of Liquefied Gases ... F. H. ATKINSON *and* S. SUMNER
Quality Control ... ... E. A. BROWN

SESSION 1968–69

The Future of the Society ... ... W. C. G. Knowles

Refrigerated Liquefied Gas Carriers (Heat Transfer—Cargo Conditioning and Commissioning) ... ... M. Z. Navaz

Indicating and Recording Instruments ... G. S. Hubbard

Control Dynamics ... ... K. Larsen

Work of the Staff Department ... ... E. W. Venner

First Steps in Control Engineering Made Easy ... ... A. R. Hinson

Joining Ships Afloat ... ... W. B. Scheelings

Tensile Testing of Steel ... R. Liston *and* J. C. Huskins

SESSION 1969–70

Technical Training and Information ... W. F. Stoot *and* T. Swiatecki

Some Notes on the Hull Survey of New Construction in Sweden ... ... O. Nilsson

Classification Procedures ... ... C. F. Algate

1966 Load Line Convention: Its Implications and Interpretations ... ... T. A. Simpson, J. M. Bates *and* L. Beckwith

Behaviour of Control Equipment in a Steam Turbine Tanker ... ... D. Gray

Some Notes on Non-Marine Work ... J. L. Savours

Index to the Transactions 1920–1970 ... R. J. Hook

SESSION 1970–71

Lloyd's Register Staff Association: The Past and the Future ... J. B. Davies, D. Gray, E. W. Venner *and* J. G. F. Warris

Model Structural Testing Techniques ... A. C. Wordsworth

Fire Detection in Unattended Machinery Spaces ... ... J. D. Bolding

The Survey of Crew Accommodation ... J. R. G. Smith *and* J. W. Barron

Application of On-line Computers in Ships ... ... J. Hancock

Some Developments in the Ministry of Defence ... ... K. J. Rawson

The Survey of Safety Equipment in Cargo Ships ... ... G. Smart

Ships Electrical Installations and Their Surveys ... ... W. De Jong

Simplified Short Circuit Calculations for Marine Alternating Current Networks K. Morris *and* K. H. Klemm

Buckling as a Mode of Failure in Ship Structures ... J. I. Mathewson *and* A. C. Viner

SESSION 1971–72

Anchoring and Mooring ... ... A. K. Buckle

Some Comments on Shafting and Sterntubes ... ... C. M. Bergmann

Marine Steam Turbines ... ... K. M. B. Donald

Classed Refrigerated Installations ... P. K. Coles

SESSION 1972–73

Hull Damage in Large Ships ... S. Janzen *and* O. Nilsson

Public Relations ... ... R. D. Daniel

Data Processing at Lloyd's Register ... A. J. Browne

The Printing House ... ... E. W. Rowell

Towage Surveys and Associated Work K. Van Duffelen

Some Notes on a Large Tanker Machinery Installation ... ... D. Hague

SESSION 1973–74

Lloyd's Register of Shipping's relations with IMCO and IACS ... ... R. P. Harrison

The Work of the Port of London Authority ... ... J. Richardson

A Brief Guide to the Preparation and Presentation of Technical Papers ... C. Cummings

The Structural Design of Fixed and Steerable Propeller Ducts ... ... R. F. Barton

Lloyd's Register and the Shipbuilder ... A. R. Belch

The International Conference on Marine Pollution, 1973 and resulting International Convention ... ... R. P. Harrison, F. H. Atkinson *and* R. J. C. Dobson

SESSION 1974–75

Fire Protection, Detection and Extinction in Ships ... ... G. Coggon

Surveying OBO's and Large Bulk Carriers G. S. McIntosh

Some Notes on Writing Damage Reports L. D. Phillip

Some Practical Aspects of Moulding G.R.P. Yachts and Small Craft ... J. Tyler *and* R. Musters

Lloyd's Register and the Marine Engine Builder ... ... A. Schiff

Index to the Transactions 1920–1975 ... R. J. Hook

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